Partington

THE

BRITISH CYCLOPÆDIA

OF THE

ARTS AND SCIENCES;

INCLUDING

TREATISES

ON THE

VARIOUS BRANCHES OF NATURAL AND EXPERIMENTAL PHILOSOPHY,

THE

USEFUL AND FINE ARTS, MATHEMATICS, COMMERCE, &c.

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INTRODUCTION.

THE value of science is best shown by its influence on the happiness and well-being of mankind. This is a truism which cannot be too often borne in mind by those who impart as well as by those who receive scientific instruction. It is a constant reference to this fact which so much enhances the real importance of our modern books of science over those of the ancient schoolmen. Deep metaphysical researches, frequently combined with an ingenious play on words, formed the prominent features in their ponderous folios; and the labour of a life-time was frequently productive of less real benefit to mankind than is now effected by the sale of a single unassuming tract really fitted to impart information. Costly domes and monkish establishments were also at one period considered as the only fanes worthy of disseminating the dogmas of scholastic science; but now its study is pursued in temples of another and far more ennobling kind. Temples dedicated to the worship of the Living God have not been considered as desecrated by being appropriated to the task of teaching man how to think rationally, as well as how to adore that great and good Being who has furnished such abundant materials for the delight and improvement of his creatures. In the course of this Introduction we purpose enquiring what are the species of scientific knowledge to which the humblest may aspire, and beyond which even the most wealthy rarely receive any essential advantage.

The structure of the universe, an acquaintance with the motions and general mechanism of the heavenly bodies, are subjects within the ken and may be rendered intelligible to the meanest capacities. The structure of the human body also, as well as its general functions, may readily be made the source of much delightful as well as profitable investigation. By combining a knowledge of optics with this branch of study, we are enabled to illustrate experimentally that most extraordinary of all natural structures—the human eye, and to show how, by the agency of certain crystalline bodies differing in their refractive power, an optical instrument may be formed which far exceeds in perfection all that the sages of ancient Greece or Rome bodied forth in optical science. This one instance may suffice to point out how important it is for the student to combine the study of nature's volume with that of the laborious deductions from experimental investigation.

Mechanical science offers at first view but few attractions to the student, and it certainly does not abound in the same moral lessons which may be acquired by a careful study of natural history; but even here a wide field of interesting investigation opens itself to the enquiring mind. He finds by a careful comparison of his most perfect mechanical agents with the frame-work of "nature's master-piece, man," that they are but clumsy attempts to

imitate the every-day work of a Being who has surrounded us with examples of his own perfection, compared with which our most ingenious inventions and highest wisdom are but foolishness.

Even the mere historical enquirer may derive considerable advantage from this branch of study, as he may thus be enabled to point out the processes by which the various gigantic monuments of early superstition were erected, and to trace the history of edifices, and to fix a date for their erection, by simply referring to the mechanism of their construction.

The changes observable throughout nature result either from the mutual actions of the minute particles of bodies exerted at imperceptible distances, and producing a permanent alteration in their constitution, or from the action of separate masses, exerted at sensible distances, and producing alterations in their relative positions. In the first case, the phenomena belong to that department of experimental philosophy which is denominated chemistry. The study of the phenomena exhibited in the latter case constitutes natural philosophy, or rather that department of experimental science to which the term physics is applied.

Thus we see that the provinces of the chemist and natural philosopher are distinct. Whilst the business of the former is to ascertain and classify the primary elements of bodies, and to trace the effects and comparative degrees of agency of the forces exerted among the minute particles of matter, which are incessantly and insensibly producing permanent changes in the constitution of these bodies, that of the latter is to classify the effects and measure the intensity of those forces which are continually tending to produce changes in the relative positions of bodies as they exist in nature, without at all effecting any change in their constitution, and hence to explain the phenomena which result from different combinations and modifications of these forces. In many cases, indeed, the same force may come within the province of each. Heat, for instance, is the object of the chemist's consideration, in as far as it is efficacious in changing the character of various substances, or in resolving compound bodies into their component elements, and uniting elementary substances into distinct compound bodies; but it also comes within the cognizance of the natural philosopher, in as far as it is the cause of alterations in the dimensions of homogeneous bodies that may be subjected to accurate measurement or calculation.

The importance of keeping steadily in view the connection between the physical sciences may be best illustrated by comparing the ancient and modern systems of astronomy; for it was the study of terrestrial mechanics that first led to the discovery of the mechanism of the universe. And the reason why the ancient theories of astronomy were so fanciful and absurd is, that ancient philosophers went to investigate what was distant, before they made themselves acquainted with what is near, and tried to know the heavens while utterly ignorant of the earth. To show the hazard of investigating one science independently of another, we shall quote the words of Mrs. Somerville, who has written a valuable work on this subject.

"The theory of dynamics, founded upon terrestrial phenomena, is indispensable for acquiring a knowledge of the revolutions of the celestial bodies and their reciprocal influences. The motions of the satellites are affected by the forms of their primaries, and the figures of the planets themselves depend upon their rotations. The symmetry of their internal structure proves the stability of these rotatory motions, and the immutability of the length of the day, which furnishes an invariable standard of time; and the actual size of the terrestrial spheroid affords the means of ascertaining the dimensions of the solar system, and provides an invariable foundation for a system of weights and measures. The mutual attraction of the celestial bodies disturbs the fluids at their surfaces, whence the theory of the tides and the oscillations of the atmosphere. The density and elasticity of the air, varying

with every alternation of temperature, lead to the consideration of barometrical changes, the measurement of heights, and capillary attraction; and the doctrine of sound, including the theory of music, is to be referred to the small undulations of the aërial medium. A knowledge of the action of matter upon light is requisite for tracing the curved path of its rays through the atmosphere, by which the true places of distant objects are determined, whether in the heavens or upon the earth. By this we learn the properties and nature of the sunbeam, the mode of its propagation through the ethereal fluid, or in the interior of material bodies, and the origin of colour. By the eclipses of Jupiter's satellites, the velocity of light is ascertained, and that velocity, in the aberration of the fixed stars, furnishes the only direct proof of the real motion of the earth. The effects of the invisible rays of light are immediately connected with chemical action; and heat, forming a part of the solar ray, so essential to animated and inanimated existence, whether considered as invisible light or as a distinct quality, is too important an agent in the economy of the creation not to hold a principal place in the order of physical science, whence follows its distribution over the surface of the globe, its power on the geological convolutions of our planet, its influence on the atmosphere and on climate, and its effects on vegetable and animal life, evinced by the localities of organized beings on the earth, in the waters, and in the air. The connection of heat with the electrical phenomena, and the electricity of the atmosphere, together with all its energetic effects, its identity with magnetism, and the phenomena of terrestrial polarity, can only be understood from the theories of these invisible agents, and are probably principal causes of chemical affinities. Innumerable instances might be given in illustration of the immediate connection of the physical sciences, most of which are united more closely by the common bond of analysis, which is daily extending its empire, and will ultimately embrace almost every subject in nature in its formulæ."

Expensive apparatus was formerly considered as essential to the study of science in any useful or tangible form; this however is as erroneous as it is to suppose that highly aristocratic establishments are essential to a well-grounded acquaintance with the principles of mathematical study. Who is there who has not heard of the unassisted labours of James Ferguson the shepherd boy? For him the figured volume of a Euclid, and the laborious investigation of a Newton, had appeared in vain, and he carved out a path of study for himself, unaided by any other light than that of his own powerful mind. His apparatus consisted of a few beads and a piece of thread; and with these he marked the relative positions of the heavenly bodies, and was enabled to show with tolerable accuracy the degrees of velocity with which they moved through space.

The useless profusion and complexity of apparatus formerly considered essential for experimental chemistry was a great obstacle to the advancement of this science in the last and preceding centuries; and it was only in the ducal palace of Magdeburg, and in the laboratories of our own Royal Society, that they were pursued with any success. Chemical apparatus was first simplified by the celebrated Priestley, who showed that a few glass tubes and a Florence flask were all that was essential to discoveries of the greatest magnitude.

We may now however proceed to trace in detail the progress of some of the most important branches of science, commencing with the employment of those simple mechanical appliances which, on account of their general utility, must have evidently earliest engaged the attention of mankind. To render our view, however, intelligible to the reader, we must first examine the nature of attraction, and trace our acquaintance with that invisible yet all-pervading energy, which acts alike on the vast frame of creation, guiding the planetary orbs in their course through space, and giving a form and character to the minutest drop of dew.

The great principle of attraction, in the Newtonian sense of it, seems to have been first examined by Copernicus. "As for gravity," says this distinguished philosopher, "I consider it

as nothing more than a certain natural appetence that the Creator has impressed upon all the parts of matter, in order to their uniting or coalescing into a globular form, for their better preservation; and it is credible that the same power is also inherent in the sun, and moon, and planets, that those bodies may constantly retain that round figure in which we behold them." Kepler calls gravity a mutual and corporeal affection between similar bodies, acting so as to produce their union; and he afterwards more positively asserts that no bodies whatever were absolutely light, but only relatively so, and consequently that all matter was subject to gravitation. Lord Bacon and Dr. Gilbert come next in order, though they added but little to our knowledge on the subject; and we must look to Newton for the first correct notions in connection with gravitation. The ancient attraction was supposed to be a kind of quality inherent in certain bodies themselves, and arising from their particular or specific forms. The Newtonian attraction is a more indefinite principle, and he states that he uses the words attraction, impulse, and propulsion to the centre, indifferently; and cautions the reader not to imagine that by attraction he expresses the modus of the action, or the efficient cause thereof, as if there were any proper powers in the centres, which in reality are only mathematical points; or as if centres could attract. So that he considers centripetal powers as attractions, though, physically speaking, it were perhaps more just to call them impulses, and he concludes by observing that what he calls attraction "may possibly be effected by impulse, though not a common or corporeal impulse, or after some other manner unknown to us. Attraction, if considered as a quality arising from the specific forms of bodies, ought therefore, with the whole list of absurd occult qualities, to be exploded. But, when we have set these aside, there will remain innumerable phenomena of nature, and particularly the gravity or weight of bodies, or their tendency to a centre, which argue a principle of action seemingly distinct from impulse, where at least there is no sensible impulsion concerned. Nay, what is more, this action in some respects differs from all impulsion we know of, impulse being always found to act in proportion to the surfaces of bodies, whereas gravity acts according to their mass, and consequently must arise from some cause that penetrates or pervades the whole substance of the body. This unknown principle—unknown, we mean, in respect of its cause, for its phenomena and effects are most obvious—with all the species and modifications thereof, we call *attraction*, which is a general name under which all mutual tendencies, where no physical impulse appears, and which cannot therefore be accounted for from any known laws of nature, may be ranged."

Attraction may be divided, with respect to the law it observes, into two kinds. Firstly, that which extends to a sensible distance. Such are the attraction of gravity, found in all bodies; and the attraction of magnetism and electricity, found in particular bodies. For an account of the laws and phenomena of each, see their respective articles in this cyclopædia.

The attraction of gravity, called also among mathematicians the *centripetal force*, is one of the greatest and most universal principles in all nature. We see and feel it operate upon bodies near the earth, and find by observation that the same power operates on the other planets, primary as well as secondary; and even that this is the very power by which they are all retained in their orbits, &c. And hence, as gravity is found in all the bodies that come under our observation, it is easily inferred, by one of the settled rules of philosophising, that it obtains in all others; and, as it is found to be as the quantity of matter in each body, it must be inherent in every particle, and hence every particle in nature is proved to attract every other particle.

From attraction then arises all the motion, and consequently all the mutation, in the physical world. By this heavy bodies descend, and light ones ascend; by this projectiles are directed, vapours and exhalations rise, and rains, &c., fall. By this rivers glide, the air presses, and the ocean swells, in obedience to the laws which regulate the tides.

We may now notice that species of attraction which does not extend to sensible distances. Such is found to obtain in the minute particles whereof bodies are composed, and which attract each other at or extremely near the point of contact, with a force much superior to that of gravity, but which at any distance from it decreases much faster than the power of gravity. This is termed the *attraction of cohesion*, as being that by which the atoms or insensible particles of bodies are united into sensible masses.

This latter kind of attraction owns Sir Isaac Newton for its discoverer, as the former does for its improver. But, besides the common laws of sensible masses, the minute parts they are composed of are found subject to some others, which are thus illustrated by Newton :—" In virtue of these powers," he says, " the small particles act on one another even at a distance; and many of the phenomena of nature are the result thereof. Sensible bodies act on one another in divers ways; and we thus perceive the tenour and course of nature. It appears highly probable that there may be other powers of the like kind; nature being very uniform and consistent with herself. Those just mentioned reach to sensible distances, and so have been observed by vulgar eyes; but there may be others which reach to such small distances as have hitherto escaped observation; and it is probable electricity may reach to such distances even without being excited by friction."

These phenomena, " in virtue whereof the particles of the bodies above mentioned tend towards each other," Newton calls by a general indefinite name *attraction*, which is equally applicable to all actions by which distant bodies tend towards one another, whether by impulse or by any other latent power; and from hence he accounts for an infinitude of phenomena, otherwise inexplicable, to which the principle of gravity is inadequate. " Thus," adds our author, " will nature be found very conformable to herself and very simple, performing all the great motions of the heavenly bodies by the attraction of gravity, which pervades those bodies, and almost all the small ones of their parts, by some other attractive power diffused through the particles thereof. Without such principles, there never would have been any motion in the world; and without the continuance thereof motion would soon perish, there being otherwise a great decrease or diminution thereof, which is only supplied by these active principles."

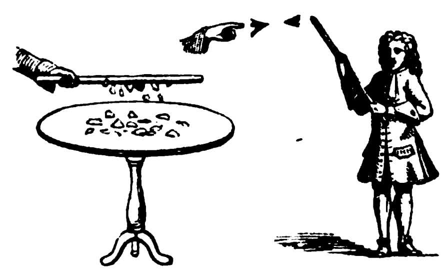
The attraction which subsists between the particles of fluid bodies was first investigated by the Academy del Cimento. But the completest series of experiments on capillary action was made by our countryman Hauksbee. He proved that it is not affected by atmospheric pressure, and succeeds equally well in *vacuo;* he showed the ascent of water and other liquids between proximate glass plates, and compared it with the rise in narrow tubes; and he ascertained the elevation to be always inversely as the width of the bore or the separation of the plates. He found that the same property belongs to marble and brass, and remarked the ascent of water in an open barometer tube filled with fine ashes. Dr. Brooke Taylor likewise performed several ingenious experiments on this subject: having joined two plates of glass at their vertical sides so as to form a sharp wedge, he dipped it in a vessel of water, and observed the liquid to rise and form a rectangular hyperbola, thus clearly exhibiting the relation of the ascent to the interval between the proximate surfaces. But he pursued the phenomena of corpuscular attraction still further, and measured the adhesion of a disk of glass to water and mercury. Seventy years afterwards this enquiry was resumed by the celebrated Guyton Morveau, who endeavoured to ground upon it the chemical theory of elective attraction. The attempt however was fallacious, because the force required to detach a disk of glass, marble, or metal, from a surface of water or mercury, is not a single effort, but combines the adhesion of the liquid particles to the solid with their cohesion to each other. In 1718, Dr. Jurin, being led to examine the phenomena of capillary attraction, proposed a theory for their explication which seemed at least plausible. He

rightly ascribed the rise of water in the cavity of the tube to the close attraction of the internal surface of the glass, though he did not perceive the way in which that force must act. He fancied the suspension of the slender column of liquid to be caused by the attraction of the ring of glass immediately *above* its summit. But such an assumption was quite illusory; for the ring *below* that limit would evidently exert an equal force in the opposite direction, and thus extinguish the influence of the former.

It is, however, to Segner that we are indebted for the first accurate view of the theory of capillary attraction. He took up the subject in 1754, and gave a different solution, distinguished by its depth, ingenuity, and general accuracy. Assuming as a principle that the attractive energy is confined to a mere exterior film of the liquid, he found the curve of the upper surface to be what is called the *Lintearia*, or the cavity of an inflated sail formed by a uniform tension. The results he obtained were perfectly accordant with the phenomena, except in the figure of a drop of water, in the determination of which he had, from overlooking the double curvature, committed a small error.

Nearly half a century more elapsed before any further attempt deserving notice was made to improve the theory of capillary attraction. In 1804, the late lamented Dr. Thomas Young resumed the investigation of this subject, and obtained a very complete solution, but which required the admission of a repulsive force among the particles of the liquid at a certain small distance. These investigations were subsequently resumed bv Mr. Ivory, who threw considerable light on the subject of capillary attraction.

The attraction which results from a disturbance in the electrical equilibrium may next be adverted to. There were some very ridiculous doctrines taught by the ancient schoolmen in connection with this species of attractive energy. They believed that there were sympathies between different bodies which caused them to attract others and elicit light when they were excited by friction. The whole train, however, of these absurdities have been swept away by the discoveries of Franklin, Davy, and Faraday. The apparatus employed by the early experimentalists in this branch of science, though very inefficient, was yet sufficiently simple. Mr. Grey, who was resident in the Charter House early in the last century, was an ingenious electrical philosopher. He is represented with his apparatus in the subjoined sketch. He was enabled to raise light pieces of paper by exciting a glass tube, and his apartments became the resort and wonderment



of the little knot of philosophers who flourished at the period, and whose proceedings were carefully chronicled by several members of the Royal Society.

This ingenious philosopher was also enabled to give a spark to the finger when presented to the tube, as is shown in the other portion of the figure. When Mr. Grey wished to increase the power of his apparatus, he went out into his balcony, and then, by the agency of a long piece of wire suspended by a silk thread, he obtained a sufficient conducting surface for his purpose. We cannot in the present place pause to compare this pigmy and ill-assorted apparatus with the giant machines employed in the Teylerian Museum, which melted bars of metal, burnt combustible bodies, illuminated the apartment, and indeed exhibited all the terrific phenomena of the very bolts of heaven. But it is a curious and interesting task to trace these incipient efforts of philosophy in her infancy, as a little more glass and metal, aided by a little more experience, would have converted Mr. Grey's apparatus into one fitted for the lecture-table in the present day.

Strictly speaking, the science of mechanics includes the laws of matter, motion, and force.

The first of these possesses the attributes of solidity and inertiæ; it is divisible as far as our senses or even our imagination can go, but we are certain that its ultimate particles must be indivisible, or at least that they are never divided in the operations of nature. In the proper sense of the term, no matter is solid; for no mass is destitute of pores into which other substances may not be introduced. Thus wood contains air between its fibres, and air contains water diffused in it in the state of vapour. With reference to the actual solidity of the particles of which firm bodies are composed, it appears certain that they act on each other without really being in contact, by means of powers connected with them, put in operation by the Author of all things. Where the forces act with great intensity, the body presents the quality of hardness, resisting any attempt to separate the particles: where their sphere of action is of some extent, it is termed elastic, and possesses the power of resuming its original dimensions, when the power which compressed or extended it ceases to act. If the repulsive force be diminished, or the cohesive increased, the bulk of the body must diminish, as when it is compressed by an external force, or when its temperature is reduced. That being always an antagonist to cohesion, by its action solids become fluid, and liquids are changed into vapours, the intermediate steps being marked and measured by their expansion.

Inertia is a term invented to express that quality of matter by which it is indifferent as to rest or motion, that passiveness to every impulse which is so decidedly its attribute. Were there no other being in the universe it must be for ever unmoved and dead; were it once put in motion it must move for ever: and they who dreamed that the universe was caused by a fortuitous concourse of atoms showed their absolute want of observation. That matter has no power to put itself in motion every one will readily admit; but it is thought by some difficult to conceive how it can be indifferent to rest. At the first view it appears that all motions decay, and that, as some cause is required for their beginning, so it is necessary to maintain them; but, if we examine more minutely, we find that there exist around us phenomena capable of producing this loss of motion, and to which therefore it must be attributed, such as the resistance of the air, friction, stiffness of cordage, &c. If these be diminished (for they can never be removed), the motion is prolonged, and to such a degree as decidedly shows that if they were entirely removed the motion would be perpetual. The quality of absolute inertia belongs only to matter in the abstract; for every atom of it with which we are acquainted acts on others, being the vehicle of the energies by which the Governor of the universe has ordered his works to be swayed.

We have seen that gravitation resides in every particle of the solar system; electricity, magnetism, and heat, are in this globe almost omnipresent; and the actions of bodies on light, and the play of chemical affinities, indicate the existence of countless forces resident in matter. But the effects of these are obviously distinct from the formation of matter itself, and cannot be explained by any material agency: besides, we see that they cannot affect our conclusions, for in our enquiries we are aware of their influence, and allow for it, considering them as unconnected with matter; as instances, we reason as if rocks were inflexible, cords pliable, and machinery void of weight, but merely conveyers of forces, and we obtain conclusions, true only in the abstract, but capable of being corrected for particular circumstances.

The sources of motion with which we are acquainted are, the energy of animated beings, the forces to which we have already alluded as implanted in matter, and the impulsion of a body which communicates its motion to another, this last being scarcely entitled to the name of force.

Where one body communicates force to another, the quantities of motion lost and gained are equal, and they are measured by the quantities of matter multiplied into the velocities; thus, if the striking body be doubled, its quantity of motion must be doubled, and if its velocity also be doubled its motion is fourfold; and in the same way when a disturbing force

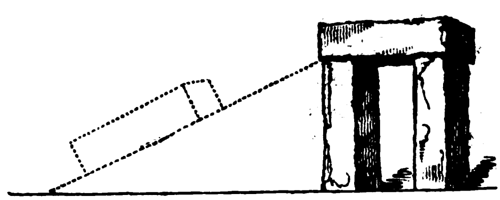
generates motion its energy is as the product of the mass moved into the velocity produced. The strength of animals is more manageable than most other movers; but the employment of it is narrowed by the limited velocity which they can produce, and by the variable nature of their exertions; and it is too often attended with circumstances revolting to humanity.

The most powerful forces which man has subjected to his industry are those of gravitation and expansion. A mass of solid matter descending from a height, a stream of water, and a current of air, afford potent movers, which are made useful by means of machinery. Still more energetic are the forces causing expansion; and the elastic force of steam, and the yet more formidable agency of gunpowder, give the means of exciting almost unlimited velocity. To devise the means of applying these to use in the most advantageous manner is the object of practical mechanics, and for the perfection of this art both theory and experiment must lend their aid, as it is equally absurd to despise the investigations of the analyst without understanding them, and to found elaborate researches on false data.

Now the mechanical powers, as they are called, are usually employed to counteract the effects of gravitation, and to produce effects which the unassisted powers of man could not otherwise accomplish; and it is astonishing how small is the change which time has effected in their arrangement. It is true that amazing advantages have been effected by their combination, but the elementary instruments were as well understood by Archimedes as by the philosophers of the present day.

Without such instruments it would rarely be possible to use any force except human strength, and the employment even of this would be very limited. In the least complicated of all mechanical efforts, that of raising a large weight as soon as it exceeded the strength of one labourer, a great difficulty would be experienced; and the average force of each individual would be proportionably less as their number increased. If, however, one man, by the aid of any mechanical instrument, can act against a force equal to tenfold his ordinary strength, and at the same time it be easy to combine the efforts of many with undiminished effect, there can be no limits to the tasks which they may perform. No force is generated in machines. All that is effected by them is to move a light body with speed, or a great weight slowly; and therefore they who have sought for a perpetual motion by the aid of machinery have but displayed their ignorance of the first elements of mechanics.

The implements employed by the early mechanics were usually of the most simple character; a bar of wood, or a mound of earth, appears to have served for the elevation of large stones that even in the present day would seem to require much more complicated apparatus. In our own island, even after the invasion of the Roman power, when the arts and civilization of the conquerors of the world might have taught the aboriginal inhabitants the use of mechanical inventions, we still find them in the most lamentable state of ignorance. The vast horizontal stones which still form part of the Druidical circle at Stonehenge have evidently been raised by the agency of an inclined plane of earth; but, as this subject has excited much controversy amongst antiquaries, we had better illustrate the matter by a diagram.



If we suppose the perpendicular stones to be erected, as shown in the figure, a mound of earth, forming an inclined plane, will readily suffice for placing the horizontal stone in its proper situation. The earthen plane may afterwards be removed, and thus all trace of the original process destroyed. By an arrangement of this kind, the celebrated traveller Belzoni was enabled to remove masses of stone which would otherwise have defied his utmost exertions. It must still, however, be borne in mind that a much greater

loss of power from friction results from the use of these primeval machines than when the improved implements of science are resorted to. In ancient times, whole nations of slaves were employed to raise pyramids and erect monuments, by which their energies were wasted and their lives ultimately destroyed, merely to gratify the caprice of a successful invader; while at the present period we are enabled to effect much greater works by the agency of machinery, and that too almost unassisted by human labour. An ingenious foreigner has published an estimate of the mechanical force set in action by the steam-engines of this country. He supposes that the *great pyramid* of Egypt required for its erection the labour of more than 100,000 men for twenty years; but that if it were required again to raise the stones from the quarries, and place them at their present height, the action of the steam-engines of England, which are managed at most by 36,000 men, would be sufficient to produce the same effect in eighteen hours.

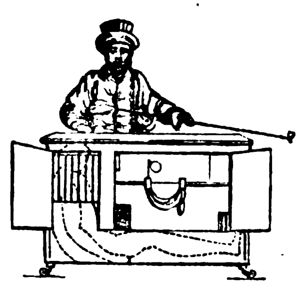
A good notion of the ordinary pursuits of the early mechanicians may be derived from their singular predilection for the construction of automata. The labour of a life-time was frequently devoted to the construction of a single figure. Among the ancients, Dædalus was famed for constructing machines that imitated the motions of the human body. Certain statues of his, it is said, had the power of moving about, and would run away unless forcibly detained. Aristotle speaks of these in his treatise *De Anima*, and affirms that the effect was produced by concealed quicksilver. This, however, could not be the case, unless the automata moved on a descending plane, like the Chinese toy called a tumbling mandarin, which, by means of mercury contained in the cavity of its body, is made to descend a series of steps. Friar Bacon and Albertus Magnus both exercised their ingenuity in the construction of androides, which appeared so wonderful to the ignorant multitude as to draw upon their inventors the dangerous imputation of being addicted to magic. Bacon is said to have constructed a brazen image capable of speaking; and Albertus Magnus formed an artificial man, in the construction of which he spent thirty years of his life. This, we are told, was broken to pieces by Aquinas, who came to see it, purposely, that he might boast how in one minute he had rendered fruitless the labour of so many years.

But these singular mechanical contrivances have also engaged the attention of many modern mechanics. Vaucanson invented some which are thus described by Beckman:—"One of them, which represented a flute-player sitting, performed twelve tunes, and, as we are assured, by wind issuing from its mouth into a German flute, the holes of which it opened and shut with its fingers. The second was a standing figure, which in like manner played on the provençal shepherd's pipe, which it held in its left hand, and with the right beat upon a drum. The third was a duck, of the natural size, which moved its wings, exhibited all the gestures of that animal, quacked like a duck, drank water, ate corn," &c.

A celebrated machine of this kind, constructed by the younger M. Droz, of the Chaux de Fronds, is thus described by Mr. T. Collinson, in a letter to Dr. Hutton, published in that gentleman's *Mathematical Dictionary*:—"Permit me to speak of another automaton of Droz's, which several years since he exhibited in England, and which, from my personal acquaintance, I had a commodious opportunity of examining. It was a figure of a man, I think the size of life. It held in its hand a metal style: a card of Dutch vellum being laid under it, a spring was touched, which released the internal clock-work from its stop, when the figure immediately began to draw. M. Droz, happening once to be sent for in a great hurry to wait upon some considerable personage at the west end of the town, left me in possession of the keys which opened the recesses to all his machinery. He opened the drawing-master himself, wound it up, explained its leading parts, and taught me how to make it obey my requirings, as it had obeyed his own: M. Droz then went away. After the first card was finished, the figure rested. I put a second, and so on to five separate

cards, all different subjects; but five or six was the extent of its delineating powers. The first card contained, I may truly say, elegant portraits and likenesses of the king and queen, facing each other; and it was curious to observe with what precision the figure lifted up his pencil in the transition of it from one point in the draught to another, without making the least slur whatever: for instance, in passing from the forehead to the eye, nose, and chin, or from the waving curls of the hair to the ear, &c.

M. Malliardet constructed an automaton which exhibited great mechanical skill. It consists of a figure of a boy resting on one knee, and holding a pencil in his hands, with which he executes not only writings, but also drawings, equal to those of the first masters. When the figure begins to work, an attendant dips the pen in ink, and lays the paper on a brass tablet before it, which is adjusted with screws to the proper position. On touching a spring it then proceeds, and when the line is finished it then returns to dot and cross the letters, when this operation is required. In this way it executes four beautiful pieces of writing in French and English, each consisting of several lines; and three drawings of landscapes; all of which occupy about an hour. The figure also exhibits all the motions peculiar to animated existence. The different parts of this machine are put in motion by means of springs; and the outline of its work is effected by the combination of various levers or ellipses traversing the circumference of metal plates or wheels. The edge being cut into different shapes at different places produces a corresponding outline in the communications, modified so as to produce the particular letter or line. The principal motions of the hand are three, two horizontal and one perpendicular, by which the thickening of the stroke by an extremely delicate operation is effected.



The clearness and precision with which a mechanical figure may exhibit specimens of the graphic art is beautifully exhibited in the article AUTOMATON, in which our artist has copied an original drawing made by the figure. The accompanying engraving shows an automaton machine which is now generally considered as a combination of mechanical skill assisted by human art. We have all heard of the automaton chess-player executed by Kempelen, and the above engraving gives its general appearance, while the dotted line shows the probable situation of the human adjunct.

The chess-player of M. de Kempelen consists of a figure as large as life, dressed in a Turkish habit, and sitting behind a table with doors, three feet and a half in length, two in depth, two and a half in height, and running on four wheels. The androides sits on a chair which is fixed to the table or commode; he leans his right arm on the table; in his left he holds a pipe, but with this arm he plays when the pipe is removed, a chess-board of eighteen inches being laid before him. The doors of the commode being thrown open, it is seen to contain wheels, levers, cylinders, and other pieces of mechanism; and in this state the machine is wheeled about the room. The vestments of the automaton are then lifted over its head, and the body is seen full of similar wheels and levers. A little door is opened in its thigh for a similar purpose; after which, every thing being disposed in its place, the automaton is ready to play, and it always takes the first move. At every motion the wheels are heard, the figure moves its head, and seems to look over every part of the chess-board. When it checks the queen it shakes its head, and thrice in giving check to the king. It likewise shakes its head when a false move is made, replaces the piece, and takes the move from the adversary. It generally, though not invariably, wins the game. M. de Kempelen, or his substitute, was always near the machine when it played, and wound it up like a watch after it had made ten or twelve moves. A small square box was frequently consulted by

the exhibitor during the game; and herein, he said, consisted the secret, which he could reveal in a moment.

But we must now pass to the history of mechanics as applied to the construction of horological machinery. Various and many are the ages and persons that claim the merit of having constructed the first machine which measured time by means of gravitating bodies as the moving and regulating powers. Germany, however, certainly is the native country both of clocks and watches. In 1544, a corporation of clock-makers was established in Paris, who secured to themselves a complete monopoly. They effected little indeed towards the improvement of their instruments; neither did any important change take place, until Hooke, in this country, and Huyghens, in Holland, about the year 1658, introduced some valuable innovations. Since that time the art has been approaching to its present accuracy as well in France as in England, and the encouragement held out by the governments of both countries has tended to excite a laudable emulation. The exact measurement of time is the subject of horology. This it is which constitutes the chief utility of the art in civil life, and still more for the purposes of science. Now this is the branch to which the attention of the English has been particularly turned ever since they engaged in it. The mode of reckoning time in which the French persist—that is to say, of admitting into its exact computation the daily variations arising from the obliquity of the ecliptic and the eccentricity of the orbit of the earth, must render superfluous a very steady march of the machines which measure it. A chronometer adjusted to apparent time in November would, if rigorously examined, appear to have lost in February; whereas, in England, the variations of the great luminary which separates day from night are reckoned once for all. In this case the accuracy of the instrument is immediately perceived and valued, while in the former method it is useless, as the thing to be measured has no settled dimensions.

To correct the apparent errors of a chronometer supposed invariable two methods exist: the one is to do as the mechanics of this country have done, to correct the errors of time—that is to say, to suppose a mean sum which shall be invariable; the other is to make the machine follow the errors of time, but this method complicates and loads the works, and is never perfect. Equation watches, showing the difference between mean and apparent time, were originally made in England, but were soon abandoned as inadequate to the end proposed. But the French have persisted in the worst method of correcting the error; and some of their most eminent artists, as the Le Roys, Le Bon, Enderlin, Passemant, and Berthoud, have squandered away as much talent in devising methods of marking both mean and apparent time by the same instrument as if the ends of navigation or the perfection of chronometry could be promoted by success. The utmost that could be gained would be to save, to those who can pay for such machines, the trouble of calculating the daily apparent variations of an instrument too accurate always to be true.

There is another circumstance worth noting in our historical view of the art. In the year 1676, the celebrated Barlow astonished the amateurs by his invention for making clocks and watches repeat the hour at pleasure. But, when the novelty had subsided, few British artists of eminence occupied themselves about it; while, in France, it became a study among the most ingenious and philosophical watch-makers; and they who have excelled in chronometry are they who have done the most to improve repeaters. Hence, then, two English inventions in horology, the one useless, the other luxurious, were soon abandoned in their native country as not congenial with the wants of society, and were seized upon with avidity in France; while here the philosophic branch of the art has been most unremittingly and successfully cultivated.

With reference to the invention of pendulum clocks, it may be proper to state that Huyghens was the first who explained the true relation between the length of a pendulum and the

time of its least vibra ions, and gave a rule by which the time of the rectilineal descent through a line equal in length to the pendulum might from thence be deduced. He next applied the pendulum to regulate the motion of a clock, and gave an account of its construction, and the principles of it, in hi *Horologium Oscillatorium* about the year 1670, though the date of the invention goes as far back as 1656. Lastly, he taught how to correct the imperfection of a pendulum, by making it vibrate between cycloidal cheeks, in consequence of which its vibrations, whether great or small, became not approximately, but precisely, of equal duration.

Robert Hooke, a very celebrated English mechanician, laid claim to the same application of the pendulum to the clock, and the same use of the cycloidal cheeks. There is, however, no real ground of dispute as to the priority of Huyghens's claim, the invention of Hooke being as late as 1670. Of the cycloidal cheeks, he is not likely to have been even the second inventor. Experiment could hardly lead any one to this discovery, and he was not sufficiently skilled in the mathematics to have found it out by mere reasoning. The fact is that, though very original and inventive, Hooke was jealous and illiberal in the extreme; he appropriated to himself the inventions of all the world, and accused all the world of appropriating his. It may be right to add that Galileo conceived the application of the pendulum to the clock earlier, by several years, than either of the periods just referred to. The invention did great honour to him and to his two rivals; but that which argues the most profound thinker and the most skilful mathematician of the three is the discovery of the relation between the length of the pendulum and the time of its vibration, and this discovery belongs exclusively to Huyghens. The method which he followed in his investigation, availing himself of the properties of the cycloid, though it be circuitous, is ingenious and highly instructive. An invention, in which Hooke has certainly the priority to any one, is the application of a spiral spring to regulate the balance of a watch. It is well known of what practical utility this invention has been found, and how much it has contributed to the solution of the problem of finding the longitude at sea, to which not only he, but Galileo and Huyghens, appear all to have had an eye.

In what respects the theory of motion, Huyghens has yet another strong claim to our notice. This arises from his solution of the problem of finding the centre of oscillation of a compound pendulum, or the length of the single pendulum vibrating in the same time with it. Without the solution of this problem, the conclusions respecting the pendulum were inapplicable to the construction of clocks, in which the pendulums used are of necessity compound.

We have now to trace the history of a very important application of the pendulum. This instrument was first proposed as an invariable standard of length by Huyghens; but Derham appears to have been the earliest who made experiments to determine its precise length when employed for that purpose. Desaguliers and Graham also pursued the subject. The numerous difficulties, however, which attended the enquiry, caused it for some time to be abandoned. The author of *Hudibras*, who most vehemently satirized the Royal Society, and especially its active member, Sir Paul Neale, little imagined what would be the result of their labours in this respect when he ridiculed the society's early attempt to form a standard of measure, and accused them of "vapouring that—

> "————————the vibration of this pendulum
> Should make all tailors' yards of one unanimous opinion."

In the year 1774, the Society for the Encouragement of Arts, Manufactures, and Commerce, offered a reward of 100 guineas for a mode of ascertaining invariable standards for weights and measures, communicable at all times to all nations; and, this offer having been continued for three successive years, Mr. John Hatton, a watchmaker, proposed, in March,

1779, to obtain a measure by applying to a pendulum a movable point of suspension, in order to ascertain the difference of length between two portions successively made to vibrate, and measure different known portions of time. Mr. Hatton's attempt, for some cause which does not appear, was not considered by the Society of Arts as entitled to the reward which they had offered, but they presented the inventor with thirty guineas. Some years elapsed without any thing further being done; but, in 1786, Mr. Hatton's plan was taken up by Mr. John Whitehurst, and a machine was constructed by him, an account of which he published in a pamphlet, entitled *An Attempt towards obtaining Invariable Measures of Length, Capacity, and Weight, from the Mensuration of Time, independent of the Mechanical Operations requisite to ascertain the Centre of Oscillation, or the true length of Pendulums.*

Whitehurst's apparatus consisted of a ball suspended by a fine flatted steel wire, forming a pendulum, the length of which could be varied by means of an adjustable clip, attached to a clock which gave motion to the pendulum. The pendulum was adjusted to vibrate forty-two and eighty-four times in a minute, and the distance between the two positions of the clip was marked upon a brass rule, which distance was afterwards determined by Sir G. Shuckburgh to be 59.89358 inches of his standard scale.

In the year 1790, we find the French nation directing its attention to a reform of its system of weights and measures. It appears that much diversity had prevailed, and that several plans of reform had been presented to the government, but not acted upon. A decree was therefore made by the National Assembly on the subject.*

In pursuance of this decree, a commission was named, consisting of Messrs. Borda, Lagrange, Monge, and Condorcet, and their report delivered in 1788 was published in the *Mémoires de l'Académie des Sciences* for 1791. Three fundamental units were considered by the French commissioners:—1. the length of the pendulum vibrating seconds; 2. a quadrant of the equator; and, 3, a quadrant of the terrestrial meridian.

The length of the pendulum vibrating seconds was rejected, on the ground of its depending upon an arbitrary division of the day into 86.400 seconds. It was stated that the regularity of the terrestrial equator was not more certain than the regularity of meridians; and that the extent of the celestial arc corresponding to that measured upon the earth is less susceptible of being determined with precision on the equator than upon a meridian. Finally, that every country has a meridian passing through it, but not an equator.

Without discussing the correctness of these opinions, we shall merely state that a quadrant of the terrestrial meridian was preferred, and the ten-millionth part of it was to be taken, under the name of "metre," as the unit of linear measure. For this purpose it was proposed to measure an arc of the meridian from Dunkirk to Barcelona, comprising more than nine degrees and a half, and this arc was supposed to be of sufficient length for the purpose. At the same time that this resolution was adopted it was determined to make, under the forty-fifth degree of latitude, such experiments as might serve to deduce the number of vibrations which would be made by a pendulum the length of which should be equal to the ten-millionth part of the quadrant of the meridian, in order that this being once known the length of the metre might be recovered by observations of the pendulum.

This grand work was commenced in 1792 by Méchain and Delambre, and carried on,

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* This document is so important that we quote the words of the reporter to the Assembly:—"Le roi étoit supplié d'écrire à S. M. Britannique, et de la prier d'engager le parlement d' Angleterre à concourir avec l' Assemblée Nationale à la fixation de l' unité naturelle des mesures et des poids, afin que, sous les auspices des deux nations, des commissionaires de l' Académie des Sciences passent se réunir en nombre égal avec des membres choisis de la Société Royal de Londres, dans de lieu qui seroit jugé respectivement le plus convenable, pour déterminer, à la latitude de quarante-cinq dégrés, ou toute autre latitude qui pourroit être préférée, la longueur du pendule, et en déduire un modèle invariable pour toutes les mesures, et pour tous les poids."

amidst the horrors of the revolution, with a perseverance, zeal, and science, which reflect the highest honour upon those engaged in it. Messrs. Biot and Arago were occupied at the same time in experiments on the pendulum; and a few years afterwards these eminent philosophers were directed to extend the meridional observations southward to Formentara, one of the Balearic Isles; and having, by means of general Roy's triangles, extended the arc to Greenwich, the whole comprised an extent of nearly thirteen degrees.

But, however valuable we may consider this work in a scientific point of view, we cannot give it a preference as a standard of measure to the length of the pendulum; and, indeed, the French themselves, though they nominally rejected the pendulum, did, in fact, virtually adopt it as the readiest means by which the metre, if lost, might be recovered. It is true that if two points be determined upon a terrestrial meridian, by means of their latitudes, these points might, if lost, be recovered by repeating the observations.

But, as this depends upon the precise determination of latitude, any circumstance which interferes with this element will materially affect the accuracy of the result. Now, it is well known that the plumb-line will be drawn from its perpendicular position by the attraction of any neighbouring mountain, or by inequality in the density of the surrounding strata. As long as the observations are confined to the same points on the same meridian, we may expect to obtain results differing only by the unavoidable errors of observation; but on any other portion of the same, or under a different meridian, we are liable to errors from local attraction, the amount of which cannot be accurately appreciated. This will sufficiently appear by an examination of the French arc, in the middle of which the length of the degree appears to decrease instead of increasing; and a similar irregularity exists in the arc measured in our own country by lieutenant-colonel Mudge, in the course of the trigonometrical survey, the degrees appearing to decrease in length in proceeding northwards, instead of progressively becoming longer. The anomaly is now known to have been occasioned by a deflection of the plumb-line of the zenith sector, either at Arbury Hill or at Clifton, amounting to more than five seconds. The length of the pendulum also is in some degree influenced by irregularity of density in the atmosphere; but the error to be apprehended in the case of the pendulum is much less than in the determination of the length of an arc of the meridian.

In the *Philosophical Transactions* for 1798, we find a very valuable communication by Sir George Shuckburgh, under the title of *An account of some Endeavours to ascertain the Standard of Weight and Measure.* The author states that he had, as early as the year 1780, taken up the idea of a universal measure, from which all the rest might be derived, by a method similar to that employed by Mr. Whitehurst, and by which all the difficulties arising in determining the actual centre of motion and of oscillation, which had so much embarrassed these experiments, would be got over.

After the death of Mr. Whitehurst, Sir George Shuckburgh obtained the apparatus with which the experiments had actually been made; but, upon attempting to repeat them, the wire by which the ball was suspended (either from rust or some unknown cause) repeatedly broke, after the pendulum had been in action fifteen or twenty hours; and, having tried other stronger wire with no better success, Sir George Shuckburgh was obliged to relinquish the attempt, and to content himself with the accurate measurement of the distance between the marks left by Mr. Whitehurst, indicating the difference of length between the two pendulums, and which was found, as we have before stated, to be equal to 59.89358 inches of his standard scale.

This standard scale was made for Sir George Shuckburgh by Mr. Troughton, who made a copy of it for Professor Pictet: this is the standard which has been taken by all Europe as indicating the linear measure of Great Britain.

In the year 1814 we find another committee of the House of Commons appointed to consider the subject of weights and measures. The report of this committee derives additional interest from its containing the examinations of professor Playfair and Dr. W. Hyde Wollaston, who were called upon by the committee for their opinions as to the best means of comparing the standards of length with some invariable natural standard. These gentlemen were decidedly of opinion that the length of the pendulum was the best standard by which a measure to be kept as a standard of length could be defined by comparison; and professor Playfair recommended that a cube of a given linear measure should be assumed as the unit of capacity, and the same when filled with distilled water of a given temperature as the unit of weight. In consequence of these examinations, the committee made, among others, the following statements:—

That the length of the pendulum vibrating seconds is 39.13047 inches, of which the yard contains thirty-six; and that the standard yard may at any time be ascertained by a comparison either with an arc of the meridian or the length of the pendulum.

That, the standard of linear measure being thus established, the measures of capacity are easily deduced from it by determining the number of cubical inches which they should contain. The standard of weight must be derived from the measures of capacity, by ascertaining the weight of a given bulk of some substance of which the specific gravity is invariable.

That the measures of capacity should be ascertained by the weight of pure or distilled water contained in them, rather than by the number of cubical inches.

That, as the weight of water appears to afford the best and most simple method of checking measures of capacity, it is desirable that all minute fractions of weight should be avoided.

That the most accurate mode of ascertaining the standard pound is to immerse in water a solid cylinder of brass containing 27.648 cubical inches, and to ascertain the difference between its weight in water and its weight in air. The difference between its weight in water and its weight in air, or the weight of the volume of water occupying the same space, is the pound avoirdupois.

In the manner recommended the standard of length is kept invariable by means of the pendulum, the standard of weight by the standard of length and the standard of capacity by that of weight.

A bill founded upon this repor was brought into parliament, and, having passed the Commons, was thrown out of the House of Lords on the motion of the late lord Stanhope. In consequence of the rejection of this bill, and the doubts which existed respecting the true length of the seconds' pendulum, which had been proposed as an invariable standard for measures of length, Mr. Davies Gilbert, in the year 1816, moved in the House of Commons the following resolution:—

"That an humble address be presented to his royal highness the prince Regent, that he will be graciously pleased to give directions for ascertaining the length of the pendulum vibrating seconds of time in the latitude of London, as compared with the standard measure in the possession of this house, and for determining the variations in the length of the said pendulum at the principal stations of the trigonometrical survey extended through Great Britain; and also for comparing the said standard measure with the ten-millionth part of the quadrant of the meridian, now used as the basis of linear measure on a part of the continent of Europe."

In consequence of his royal highness's compliance with the prayer of this address, the astronomer royal was, in the first instance, directed to perform the necessary operations; but, on his requiring further aid, an application was made by his majesty's ministers to Sir Joseph Banks, requesting that the Royal Society would be pleased to afford all the assistance

in their power for the accomplishment of the desired objects. A committee of the Royal Society was in consequence named, consisting, in addition to the president and secretaries, of Sir Charles Blagden, Mr. Davies Gilbert, Dr. Wollaston, Dr. Young, captain Henry Kater, general Mudge, Mr. Henry Browne, Mr. Rennie, and Mr. Troughton. The greater part of these distinguished individuals are now passed to that "bourne from whence no traveller returns," but their labours were of the greatest service to the cause of science. The astronomer royal made some experiments on the French plan for determining the length of the pendulum; Dr. Young proposed a method derived from that of Whitehurst, which appeared unexceptionable, but which, from some difficulties in the execution, was not put in practice; captain Kater availed himself of a property of the pendulum demonstrated by Huyghens and after nearly two years passed in experiments, and in contriving proper apparatus, and methods of observing, succeeded in obtaining the length of the pendulum vibrating seconds by a method free from all objection but the unavoidable and unimportant errors of observation. But, before we proceed, we must endeavour to make our readers understand precisely what is meant by the length of the pendulum, and how it furnishes an invariable standard of measure. And here we must observe that we are not writing for mathematicians, but for the purpose of rendering the subject generally intelligible.—A rod, or any substance suspended from a certain point, and made to vibrate, is called, in common language, a pendulum. Suppose a cylindrical rod or thick wire, fifty-two inches long, to be suspended by one end, and to vibrate; and suppose a small bullet attached to a very fine thread be hung up and also made to vibrate, the distance from the centre of the bullet to the point of suspension being thirty-nine inches. This thread and bullet, and the rod, will make the same number of vibrations in the same time, though the one is fifty-two inches long and the other only thirty-nine. These two pendulums, because they perform the same number of vibrations in the same time, are said to be equal, and the length of *the pendulum* in both cases is nearly thirty-nine inches.

We perceive, then, that in the case of the rod the length of the pendulum is measured from the point of suspension to another point which is distant from it about two-thirds of the length of the rod, and this point is called the centre of oscillation. The length of the pendulum, then, means the distance between the point of suspension and another point, called the centre of oscillation. Now, the place of the centre of oscillation is dependent upon the figure of the body, or upon the arrangement of the parts of which it is composed. Suppose the rod, of which we have spoken, to be furnished with a sliding weight which may be moved upon it. By shifting this sliding weight, the figure of the body, and consequently the place of the centre of oscillation, would be changed, and the rod would no longer vibrate in the same time as before; *the length of the pendulum*, therefore, would be different, though the length of the rod remains the same.

To compute the place of the centre of oscillation, and to find in that way the length of the pendulum, is known to be a problem of extreme difficulty, if not of impossibility. The computation requires that the body employed as a pendulum be of perfectly regular figure, and of uniform density throughout, desiderata which, in the strict sense of the terms, we know to be unattainable. It is not, therefore, surprising that the experiments which were formerly made for determining the length of the pendulum should have led to erroneous results.

Captain Kater's method is free from the embarrassments which arise from irregular density and figure. Let a pendulum be made to vibrate upon a certain point of suspension, and suppose it possible to find its corresponding centre of oscillation. Now, let the pendulum be inverted, and suppose it to vibrate upon its centre of oscillation; the former point of suspension will, under this new arrangement, become the centre of oscillation, and the

number of vibrations in equal times will be the same in either position. This property of the pendulum was first demonstrated by Huyghens.

But of what use, it may be asked, is this theorem, when the centre of oscillation cannot be found? True: but, in the method which we are describing, the centre of oscillation is brought to a point which it is previously decided that it shall occupy. Let the rod of fifty-two inches long have a knife-edge at one end, to serve as a point of suspension, and let another knife-edge, facing it, be fixed in the rod, at about two-thirds of its length from the first; let the rod also be furnished with a sliding weight. Now suspend the rod upon the knife-edge which is at its end, and determine the number of vibrations made by it in twenty-four hours. Next, cause the rod to vibrate upon the other knife-edge, and determine also the number of vibrations made during the same period. This will probably differ from the number in the first position. Shift the weight upon the rod until the number of vibrations, in either position, becomes the same. Having effected this, the one knife-edge being the point of suspension, it is evident from what we have said that the centre of oscillation has been brought to coincide with the other knife-edge; and the distance between the knife-edges, in inches and parts, is the length of the pendulum due to the observed number of vibrations, from which the length of the pendulum vibrating seconds may be calculated without difficulty. The length of the pendulum, therefore, may now be determined at pleasure, with little more trouble than is necessary for the comparison of two standard scales. Captain Kater's experiments are minutely detailed in the *Philosophical Transactions;* and we shall merely state that their result gave, for the length of the pendulum vibrating seconds in vacuo, and reduced to the standard of the seconds' pendulum (which is an invariable standard), an amount equal to 39.13929 inches of the present day, and if we wished at any time to recover the standard we should have, by simple proportion, 39.13929 to 100 as 36 to 91.978 nearly —the length upon the scale which would be equal to our present standard yard.

Having determined the length of the pendulum, captain Kater proceeded to compare the French metre with Sir George Shuckburgh's scale. For this purpose, two bars of platina were sent from France, the one being precisely the length of the metre, and the other having this length marked upon it by two fine lines. These had been verified with the utmost care by M. Arago; and the metre was found to be equal in length to 39.37079 inches of Sir George Shuckburgh's scale. The next object was to determine the variation in the length of the seconds' pendulum, at the principal stations of the trigonometrical survey. For this purpose captain Kater employed an apparatus which gave the *relative* lengths of the pendulum at the different stations; and, knowing the absolute length of the seconds' pendulum at London, he was enabled readily to deduce its length at each station where the experiments were made, with the same certainty as if it had actually been measured there. Several stations were visited, from Unst, the most northern of the Shetland Isles, to Dunnose, in the Isle of Wight; and an account of these operations forms the third part of the *Philosophical Transactions* for 1819.

The French sçavans had employed an apparatus contrived by Borda for determining the length of the pendulum. It consists of a ball of platina, most carefully made, and suspended from a knife-edge by a very fine wire. This mode requires the place of the centre of oscillation to be found; but the great care with which the ball was figured, and the trying it in various positions, enabled these gentlemen to attain an accuracy of result which, from theóry, might have been supposed impracticable.

In the year 1817 M. Biot made experiments at the same stations, at Unst and Leith, which during the following year were visited by captain Kater; and he there determined, by means of Borda's apparatus, the length of the seconds' pendulum, by actual measurement, in parts of the metre. This being converted into English inches, we find that M. Biot's

measurement of the pendulum exceeds captain Kater's determination not quite two ten-thousandths of an inch at Unst, and at Leith falls short of it rather more than that quantity, the mean difference being absolutely insensible. This very near agreement of results, obtained by methods totally dissimilar, authorises the conclusion that the determination of the length of the pendulum vibrating seconds, at London, cannot be far distant from the truth, —a fact which it is of the greatest importance to establish.

Of the various machines of luxury or utility which are in use among civilized nations, none have been more generally adopted than *wheel carriages*, and a brief notice of the history of their construction will very advantageously illustrate the progress of this branch of mechanical philosophy. In some of the colder parts of Europe and America, where ice is to be met with in considerable quantities, sledges are still much in use, as they may be made to pass over the face of a lake, or frozen snow, with nearly as much ease as a plate of smooth metal would upon one of glass.

To understand the advantages which a wheel carriage possesses over these primeval machines, it will only be necessary to bear in mind the different degrees of friction which arise from rubbing and rolling motions, and that in the former of these cases the sliding of a sledge must of necessity generate a degree of friction which will materially retard the motion of the body, but that, when we apply a wheel beneath, the rubbing motion is converted into a rolling operation, and the friction is materially diminished.*

Thus we find that the sledge was speedily superseded by the car, and the latter vehicle by a complete carriage supported on four wheels. But the ancient mechanics rarely paused in the progress of change, and we generally find some most extraordinary attempts to excite the wonder of their contemporaries coupled with each step in the march of really useful improvement. Thus a flying carriage speedily succeeded to a terrestrial anti-attrition machine. Innumerable indeed are the schemes that have been proposed by the learned at different periods, to enable man to support himself in the air by the means of artificial wings, &c., and some of these ingenious contrivances have formed the labours of the most distinguished mechanical geniuses which are recorded in the early annals of science.

Bacon, and an Italian priest named Francisco Lana, endeavoured to accomplish it by means of two thin hollow globes, exhausted of air, which, being considerably lighter than that fluid, were intended to sustain a chair suspended to their lower extremity, and on which the aëronaut might be seated. But Dr. Hook, in a work published some time after the *Prodromo* of Lana, plainly showed the fallacy of the attempt, though without in the least attempting to deny the possibility of eventually effecting this object.

Bishop Wilkins, who was also a disciple of the flying system, describes a species of land-sailing vessels or chariots, which were then commonly used in China: and it is rather a curious fact that a German count, possessing as much of modesty as the generality of foreign

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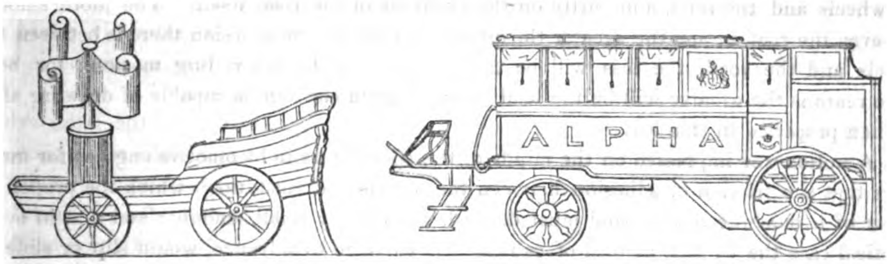
* The amount of friction, though not very considerable, in a piece of light wood, may yet be rendered sufficiently apparent if it be placed upon an inclined plane: at a small angle it will not slide down; should, however, a piece of metal of the same weight be substituted for the wood, it will immediately descend. This then shows that the smoother the surface the less the friction.

It will thus be seen that the loss of power from friction may differ very materially in the same machine by the employment of different materials, and Mr. Emerson has shown that when a cubic piece of wood of eight pounds weight moves upon a smooth plane of soft wood, at the rate of three feet per second, its friction is about *one-third* of the weight; but, if it be rough, the friction is little less than *half* the weight. On the same supposition, when both the pieces of wood are very smooth, the friction is about *one-fourth* of the weight; the friction of soft wood on hard, or of hard wood on soft, is *one-fifth*; of hard wood upon hard wood, *one-eighth*; and of polished steel moving on steel, *one-fourth* of the weight. It is also found that dissimilar metals produce the least friction, and of these brass and steel are the best adapted for practical purposes.

mechanics, has lately given to the public, as his own, an invention which has been known in Europe, and occasionally employed in Asia, for the last 400 years.

We may, however, quote a description of one of these sailing carriages from an old work on physics, which will furnish a tolerably good index to their general construction. "The body of the machine should not be large, nor placed very high, not only to prevent overturning, but that its motion may not be thereby impeded; for the velocity will be in proportion to the force of the wind on the sails to that on the body of the machine. Therefore, if they be both equal, it will stand still; or, if the force on the body be greatest, it will go backwards, unless there be a contrivance to lock the wheels. The upper part of the machine may be made to take off when the wind is contrary; and there may be another set of sails placed between the two hind wheels, which will considerably increase its velocity. But after all, for general use, a common carriage must be preferable; for this cannot be expected to go up a moderate ascent without great difficulty; nor down a declivity, when there is a strong wind, without danger; and even on level ground, if the road be rough, its progress must be very slow, attended by both difficulty and danger."



To render this description intelligible we have in the above figure appended a view of one of the best of these carriages, and by its side have placed the great wonder of modern locomotion—a steam carriage.

The employment of an internal mechanism to impel waggons on a plane road is of very early date, but the first application of the steam-engine to this purpose took place, we believe, in the Royal Arsenal at Paris, towards the close of the last century. From this time till 1802 but little progress appears to have been made in the use of this species of wheel carriage; but, about the latter period, Mr. Trevithick commenced a series of experiments on the use of the high-pressure engine for the above purpose. In 1804 a steam-carriage was in operation on the rail-road at Merthyr Tydvil, in South Wales. On the occasion of its first trial, it drew after it as many carriages as contained ten tons of iron a distance of nine miles. It performed this journey without any fresh supply of water, and travelled at the rate of five miles an hour.

It is a singular fact in the history of this invention that much of time and ingenuity were in the first instance vainly expended in attempting to overcome a difficulty which in the end turned out to be purely imaginary. To comprehend distinctly the manner in which a carriage is propelled by steam, let us suppose that the wheels of a common carriage be locked, the carriage being placed on a level road. Let the force be now ascertained experimentally which would be necessary to drag the carriage along the road, the wheels slipping or scraping along the surface. Again, suppose the wheels disengaged so as to be at liberty to revolve; let another carriage be attached to the first, behind it, so that the one cannot proceed without dragging the other along with it; let this other carriage be loaded so that its own weight, together with that of its load, shall be equal to the force which was found necessary to drag the first carriage when the wheels were locked. If the wheels of the first carriage be now turned, by force applied to their spokes or rims, it will be found that they will scrape or

slip on the road. This will be obvious on the least consideration; for the load which is now attached to the carriage, so as to resist its progressive motion, is exactly equal to that which in the former case was sufficient to move the carriage, the wheels being locked. In each case the resistance to be overcome is the friction of the wheels of the first carriage with the road; and consequently, as in the former case it was unable to overcome this resistance, so in the latter this resistance is sufficient to overcome the same load. But, if the weight of the second carriage be diminished so as to be less than that which would be necessary to move the first carriage, the wheels being locked, then, on causing the wheels of the first carriage to revolve by any force applied upon their spokes or rims, the first carriage will necessarily advance, drawing the second after it. This must obviously happen, because the weight of the second carriage is less than that which is necessary to overcome the resistance of the friction between the wheels of the first carriage and the road.

An experiment of this kind will obviously determine the load which any carriage is capable of drawing after it, by the force applied on the wheels to cause them to revolve, and the amount of this load will depend partly on the quantity of adhesion which subsists between the wheels and the road, and partly on the evenness of the road itself. The more smooth and even the road is, and the greater the quantity of friction or adhesion there is between the wheels and the road, the less will be the obstructions to the rolling motion: for both these reasons the greater will be the load which a given carriage is capable of drawing after it when propelled in this way.

A notion was impressed on the minds of the speculators in locomotive engines for many years that the friction or adhesion between the wheels and road, upon which the propelling power of a machine of this kind must depend, was of very small amount; and that in every practical case the wheels, instead of causing the carriage to advance, would slip or slide on the road, or that, if the carriage advanced, still that a portion of the moving power would be thus lost. It is singular that it should never have occurred to these ingenious persons to ascertain by actual experiment the amount of adhesion in any particular case between the wheels and the road: had they done so, we should probably have found at this time locomotive engines in a much more forward state of perfection than that to which they have really attained.

The formation of the Liverpool and Manchester railway may be considered as forming an era in steam locomotion. When this project was undertaken it was not decided what moving power it might be most expedient to adopt as a means of transport on the proposed road: the choice lay between horse-power, fixed steam-engines, and locomotive engines; but the first, for many obvious reasons, was at once rejected for one or other of the last two. It will be obvious that the steam-engine may be applied by two distinct methods to move waggons either on a turnpike-road or on a railway. By the one method the steam-engine is fixed, and draws the carriage or train of carriages towards it by a chain extending the whole length of the road on which the engine works. By this method the line of road over which the transport is conducted is divided into a number of short intervals, at the extremity of each of which a steam-engine is placed. The waggons or carriages, when drawn by any engine to its own station, are detached, and connected with the extremity of the chain worked by the next stationary engine; and thus the journey is performed from station to station by separate engines. By the other method the same engine draws the load the whole journey, travelling with it.

A premium of 500*l.* was offered by the directors for the most improved locomotive engines to run on the Liverpool and Manchester railway, under the conditions that they should produce no smoke, that the pressure of the steam should be limited to fifty pounds on the square inch, and that they should draw at least three times their own weight at the rate of

not less than ten miles an hour, that the engine should be supported on springs, and should not exceed fifteen feet in height. Precautions were also proposed against the consequences of the boiler bursting, and other matters not necessary to mention more particularly here. The proposal was announced in the spring of 1829, and the time of trial was appointed in the following October. The engines which underwent the trial were the *Rocket*, constructed by Mr. Stephenson; the *Sanspareil*, by Mr. Hackworth; and the *Novelty*, by Messrs. Braithwaite and Ericson: of these, the *Rocket* obtained the premium.

A line of railway was selected for the trial on a level piece of road about two miles in length, near a place called Rainhill, between Liverpool and Manchester; the distance between the two stations was a mile and a half, and the engine had to travel this distance backwards and forwards ten times, which made altogether a journey of thirty miles. Great improvement has subsequently been made in the working parts of the engines now running on the Liverpool and Manchester railway, though there is no alteration in their principle, and a corresponding increase of speed and power has been thereby obtained.* One of the engines lately constructed for the Manchester railway ran 23,000 miles with the most trivial repairs, making every day four or five journeys of thirty miles each.

Passing from the steam-carriage as we find it employed on a rail or track road, we come next to consider its usefulness on a common highway. Those who have witnessed the daily journeys of one of these engines by one of the most crowded thoroughfares in the metropolis can have but one opinion as to the ultimate employment of steam power as a medium of transport from one city to another. In a great commercial country like Great Britain, extending as it does its ramifications to every branch of natural and artificial produce, it is almost superfluous to remark that a vast capital is sunk annually in the mere transport of marketable commodities, and which is not only a loss to the seller, as being an unproductive outlay, but entails a heavy increase of expense to the buyer also upon every article of daily consumption. Any means, therefore, that will accelerate the conveyance, and at the same time reduce materially the expense of carriage, offers itself as a national benefit. This desideratum is effected by general locomotive conveyance, and the probability is that the steam power is in this, as well as in many other of its applications, still but in its infancy.

In the attempts which have been made to adapt locomotive engines to turnpike-roads, the projectors have aimed at the accomplishment of two objects: first, the construction of lighter and smaller engines, and, secondly, increased power. These ends, it is plain, can only be attained, with our present knowledge, by the production of steam of very high temperature and pressure, so that the smallest volume of steam shall produce the greatest possible mechanical effect. The methods of propelling the carriage have been in general similar to those used in the railway engines, viz. either by the cranks placed on axles, the wheels being fixed upon the same axles, or by connecting piston-rods with the spokes of the wheels. In some carriages, the boiler and moving power, and the body of the carriage which bears the passengers, are placed on the same wheels. In others, the engine is placed on a separate carriage, and draws after it the carriage which transports the passengers, as is always the case on railways.

* Mr. Stephenson states that a speed of forty miles an hour with a light load has been attained, and that an engine might be constructed to run 100 miles within the hour, although at that velocity the resistance of the atmosphere would be considerable. He further says that engines are now made with eight times the power of the Rocket, yet with little more weight upon any individual point of the rail, the load being equally divided upon six wheels instead of four, and the machinery placed in a more advantageous situation than formerly. Among other improvements is that of making the tubes which form the flues of the boiler more numerous and of smaller diameter than before, and of brass instead of copper. The boiler introduced by Mr. Perkins has also been found advantageous.

The chief difference between the steam-engines used on railways and those adapted to propel carriages on turnpike-roads is in the structure of the boiler. In the latter it is essential that, while the power remains undiminished, the boiler should be lighter and smaller. The accomplishment of this has been attempted by various contrivances for subdividing a small quantity of water, so as to expose a considerable quantity of surface in contact with it to the action of the fire: spreading the water in thin layers or flat plates—inserting it between plates of iron placed at a short distance asunder, the fire being admitted between the intermediate plates—dividing it into small tubes, round which the fire has play—and introducing it between the surfaces of cylinders placed one within another, the fire being admitted between the alternate cylinders. All these plans have been resorted to by different projectors; but without tracing the various steps in the history of steam locomotion by which a rude and heavy machine has been converted into a light and elegant carriage, fitted almost for every degree of velocity, it may be enough to state that a committee of the House of Commons came to the conclusion "that the substitution of inanimate for animate power is one of the most important improvements in the means of internal communication ever introduced."*

The art of *building* is indebted, in a very extraordinary degree, to the labours of the scientific mechanic. With respect to the origin of architecture, and the several periods to which its advances towards perfection are to be referred, it would be a waste of time to enter into an enquiry of any great length. The great antiquity of building is self-evident. When men first felt the inclemencies of the season it had its beginning, and has spread wherever the severities of climate demand a shelter or a shade. Its rudiments may be traced in the hut of the Indian, and the Greenlander's cave, as well as in the proudest temples of ancient Greece. It is easy to conceive that, in the early stages of society, genius had expanded but little. The architect's first efforts were but vague, and the structure he erected simple, perhaps no more than a number of trees, leaning together at the top, in the form of a cone, interwoven with twigs, and plastered with mud, to exclude the weather. In this early period we may also suppose each desirous to render his own habitation the

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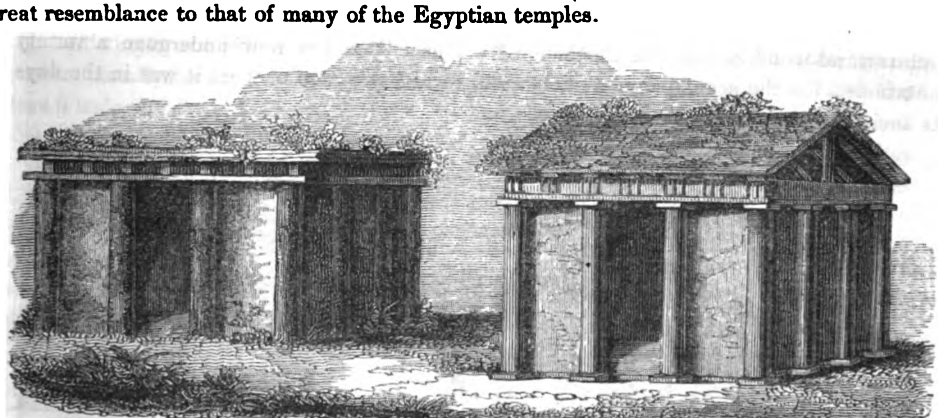
* It has been argued, with some show of truth, that the introduction of the steam-carriage will have the effect of injuring the agricultural interests; but the answer given by Colonel Torrens, in his evidence before a committee of the House of Commons, is so lucid and convincing that we readily avail ourselves of it to illustrate the advantages of steam locomotion. Having been requested by the committee to state his reasons for believing that agriculture would be benefited by the substitution of inanimate for animal power, he answered, "I conceive that agriculture is prosperous in proportion as the quantity of produce brought to market exceeds the quantity expended in bringing it there. If steam-carriages be employed, instead of carriages drawn by horses, it will be because that mode of conveyance is found the cheapest. Cheapening the carriage of the produce of the soil must necessarily diminish the quantity of produce expended in bringing a given quantity to market, and will therefore increase the net surplus, which net surplus constitutes the encouragement to agriculture. For example, if it requires the expenditure of 200 quarters of corn to raise 400, and the expenditure of 100 more on carriage to bring the 400 to market, then the net surplus will be 100. If, by the substitution of steam-carriages, you can bring the same quantity to market with an expenditure of fifty-quarters, then your net surplus is increased from 100 to 150 quarters, and consequently either the farmer's profit or the landlord's rent increased in a corresponding proportion. There are many tracts of land which cannot now be cultivated, because the quantity of produce expended in cultivation and in carriage exceeds the quantity which that expenditure would bring to market. But, if you diminish the quantity expended in bringing a given quantity to market, then you may obtain a net surplus produce from such inferior soils, and consequently allow cultivation to be extended over tracts which could not otherwise be tilled.

"On the same principle, lowering the expense of carriage would enable you to apply additional quantities of labour and capital to all the soils already under cultivation. But it is not necessary to go into any illustrative examples to explain this, it being a well-known principle that every improvement which allows us to cultivate land of a quality which could not previously be cultivated also enables us to cultivate in a higher manner lands already under tillage."

most attractive, as well as the most convenient. Here, then, we find the first dawn of architecture as a fine as well as a useful art.

At a very early period, as might be expected, architecture had made some progress; for we are informed, in holy writ, that Cain "builded a city, and called the name of the city after the name of his son, Enoch; but we are wholly in the dark as to the perfection to which it had attained when that awful visitation of the Almighty, the universal deluge, obliterated almost every mark of previous habitation. The next mention of it is in the account of the building of the tower of Babel, which was stopped by the confusion of tongues. This was soon surrounded by other buildings, and walls of great magnitude, and here, therefore, we may date the origin of post-diluvian architecture. Whatever celebrity, however, the wonders of Babylon attained among the ancients, no remains of them have come down to us, and it is the massive edifices of Egypt, built apparently rather for eternity than time, that now excite our admiration as the most ancient as well as stupendous structures existing upon earth. We must not however, under this epoch, omit to notice the remains, and, alas! the only remains, of Indian and Mexican greatness. But for the splendid ruins at Delhi and Agra, and that most singular specimen in the island of Elephanta, we should scarcely have known of the existence of civilization among the ancient Hindoos; and the aborigines of Mexico were regarded as little better than savages before the late discoveries by Mr. Bullock. The dates of these buildings are wholly unknown; but, from the great similarity they bear to those of Egypt, it is supposed they are of at least equal antiquity.

It may not be improper here to remark that the latter country is considered to have been peopled by a colony from India. About the same general date may also be classed the architecture of the Hebrews, or, as it is more properly characterized, the Phœnician style, the greatest monument of which was the far-famed temple of Solomon. The description of this edifice as it occurs in the sacred text will be found, on an accurate consideration, to bear a great resemblance to that of many of the Egyptian temples.



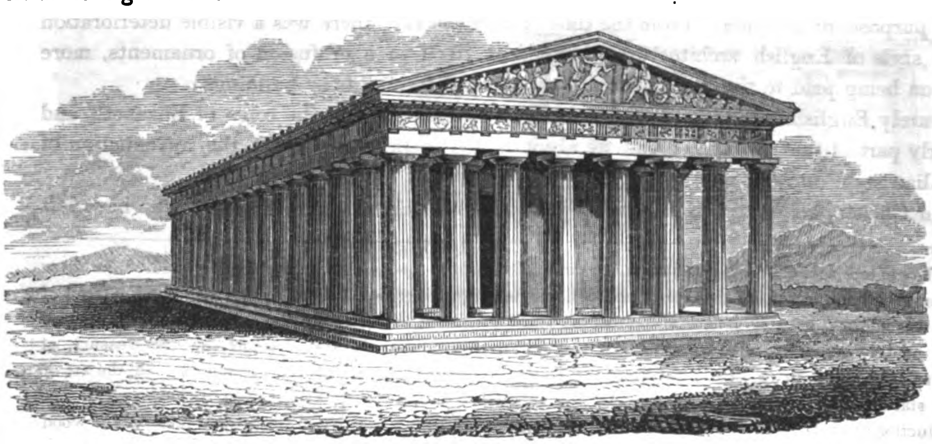
In the accompanying sketches one figure furnishes a view of what may be considered as the first attempts of the uneducated artisan, regardless only of strength in the erection of his edifice, and the second will serve to illustrate the advance towards a higher style of art, and when the modern mode of combining strength and ornamental design in a roof had been discovered. It is obvious that the first step would be to remove the foliage of the tree which was ultimately to form the walls of the edifice, and then to employ the larger boughs to construct the roof. From this follows a species of cornice for ornamenting the top line of the

edifice, and we ultimately find the pediment and "jutting frieze" giving a definite architectural form and finish to the whole. This brings us to the first dawn of Grecian art; and now the column of polished marble succeeded to the rough and unhewn tree, and the chiselled ornament took the place of a garniture of boughs. The sister art of painting was also soon introduced.

The architecture of a people is an important part of their history. It is the external and enduring form of their public life, an index to the state of knowledge and social progress. Some persons, indeed, have regarded the noblest monuments of antiquity but as the marks of "a slavish submission to a hierarchy." But it may safely be asserted that the progress which man has made in the arts is mainly due to the influence of religious systems, and that the great improvements which have thus been gradually effected have at last descended to the humblest dwellings.

Temples formed by human hands, though under the immediate direction of the Deity, have been raised to perpetuate the forms of worship earliest known on the earth; and, when that worship was degraded by a substitution of the creature for the Creator, we still find the noblest energies of man engaged in the erection of similar edifices. Civil architecture made but little progress till the time of Pericles, when some of the noblest efforts of human ingenuity were executed at Athens. This celebrated city was the capital of Attica, in Greece. The city was covered with magnificent temples; and, whilst the spoils which resulted from her conquests in Persia furnished the means for a most profuse expenditure, it was fortunate for mankind that the highest taste directed the outlay of its rulers. The most ancient part of the city of Athens was built upon a rock called the Acropolis, and contained the most sumptuous buildings with which Athens was adorned. The monuments called the *Elgin Marbles* formed part of the fragments of these edifices; and we need hardly add that they are now preserved in the British Museum in a way as praiseworthy to the nation as it is to the taste of its government.

Athens contained many splendid temples; but the greatest wonder in this world of architectural wonders was the Parthenon.* This edifice has now undergone a variety of mutations; but the accompanying sketch will furnish a notion of what it was in the days of its ancient greatness.



It may here be proper to remark that the earliest edifices of Greece were by no means remarkable for beauty, as even the temples were little better than rude huts, sheltered, if

* Phidias, the principal architect employed in the erection of this magnificent structure, was the great master of the art of statuary. He was born at Athens about 480 years before the Christian era. Athens was at that

sheltered at all, by branches of laurel and other trees. On the decline of Greece, and its conquest by the Romans, the arts appear to have been transferred to the conquerors; but among that hardy and warlike race it made little progress before the reign of Augustus. Under the auspices of that munificent monarch it rapidly attained to almost as great perfection as in the favoured country of the arts in its best days, and the "eternal city" owes much of its present estimation to the noble structures erected by him and his successors. With Rome, however, the art decayed, and was overwhelmed in the general confusion and oblivion of learning, art, and science.

The existing monuments in Great Britain which are supposed to be anterior to the Roman invasion of this island are classed, whether correctly or not we shall not here enquire, under the general term Druidical or Celtic. The most remarkable of these monuments, both for preservation and arrangement, is Stonehenge, on Salisbury Plain, in Wiltshire. Here we find stones of very large dimensions, placed upright in the ground, and forming a series of concentric circles. They are not merely rude masses, like those of Avebury and Silbury Hill, but they have evidently undergone some sharping and rubbing down, so as to form tolerably regular parallelopipedons. We here observe also two stones placed upright, like posts or pillars, and another large stone placed over them, like an architrave or lintel; the lintel is also secured by means of mortises and tenons. All this indicates certainly a regular principle of construction. The attention of the Saxons in our own country, probably about the eighth century, was excited by the remains of edifices raised by the Romans during their residence in England. These, in their newly erected churches, they aspired to imitate; but their workmen, ignorant of the principles which guided the architects of those splendid ruins, produced only the general outlines of their patterns; and those clumsy forms continued to be practised, with little alteration, till the beginning of the twelfth century. But now, as the tumult excited by the invasion subsided, and the genius of the nation improved, a taste for the fine arts began to show itself, and architecture assumed a different and novel aspect. Instead of tamely treading in the steps of their predecessors, the architects of those times devised a style as scientific as it was grand, and as beautiful as new. The pointed or Saxon style, usually termed Gothic, is peculiarly fitted for ecclesiastical edifices; and the long-drawn aisle and fretted screen, with its dim and shadowy light, are admirably adapted for the purposes of devotion. From the time of Edward III., there was a visible deterioration in the style of English architecture, which lost itself in a profusion of ornaments, more attention being paid to the details than to the general forms of the buildings.

Purely English architecture made but little progress during the reign of Elizabeth and the early part of that of James; and we are indebted to Inigo Jones for the introduction of the Italian style into our edifices.*

Sir Christopher Wren, Kent, and Wyatt, are the only modern architects who have left

period the general school of arts and letters. From Homer, whose poems Phidias had deeply studied, he drew images of greatness, which he afterwards moulded with earthly materials in a kindred spirit; and the mind of Phidias was adorned with all the knowledge which could be useful to his profession. He was also skilled in history, poetry, geometry, and the optics of that day; and, whilst Pericles commanded the treasury at Athens and the allied states, he had the means of giving full scope to the efforts of his genius. In the art of forming statues of bronze, both for the number and excellence of his works, Phidias was without a rival. In the production of ivory statues also he stood alone; nor did he disdain to work in the meaner materials of wood and clay, or to execute articles of the smallest mechanism. Among the most celebrated of the works which Phidias executed with his own hands was a statue of Minerva, which adorned the interior of the Parthenon.

* This distinguished English architect was born in 1572, and apprenticed to a joiner; but, having distinguished himself in landscape painting, he was sent to Italy by the earl of Pembroke, who was at the expense of his education. His principal work, the Banqetting-house at Whitehall, still remains an enduring monument of his genius, and the style that he first introduced into this country.

works which will outlive the periods of their erection. The greatest work of the latter gentleman, in Gothic architecture, was Fonthill Abbey, the merits of which building, when we consider that the architect had no model to work from, are truly extraordinary. The purest taste formerly reigned throughout the whole of this splendid structure; and Mr. Britton, in his graphic delineations, has presented to succeeding professors a legacy of incalculable value.

We have seen that the remains of Grecian architecture and statuary, which have escaped the ravages of time, and descended to us in somewhat of a perfect state, continue to be viewed with enthusiastic admiration, even after every attempt which the most skilful modern artists have made to rival or exceed them. Their basso-relievos, their coins, their gems and cameos, are not of less admirable execution; and there is much reason to believe that in painting they were not less eminent, although, from the perishable nature of the specimens of this branch of the arts, but few models have descended to us, and none of these probably of much intrinsic value. This leads us to the connection which must of necessity subsist between the arts of painting and architecture, as well as sculpture. Among the ancient paintings employed in architectural edifices which have reached modern times, the principal have been some specimens of fresco, rescued from the ruins of Adriana, Herculaneum, and Pompeii, on which it cannot be supposed that much graphic skill would be employed. To these we have to add the Aldrobandine nuptials, the figures on the pyramid of Cestius, a figure of Rome on the palladium, and some similar performances, which we cannot suppose to have been works of the highest value. It would, therefore, be unreasonable, from the evidence which we possess, to refuse to the early architects that pre-eminence in painting which they undoubtedly possessed in the corresponding branches of the arts of design. On this subject Sir Joshua Reynolds, with truth, remarks that "there can be no doubt but that the same correctness of design was required from the painter as the sculptor; and if the same good fortune had happened to us in regard to their paintings, to possess what the ancients themselves esteemed their masterpieces, which is the case in sculpture, I have no doubt but we should find their figures as correctly drawn as the Laocoon, and probably coloured like Titian. What disposes me to think higher of their colouring than any remains of ancient painting will warrant is the account which Pliny gives of the mode of operation used by the celebrated Apelles. In regard to their power of giving peculiar expression, no correct judgment can be formed; but we cannot well suppose that men who were capable of giving that general grandeur of character, which so eminently distinguishes their works in sculpture, were incapable of expressing peculiar passions.*

The causes of the remarkable pre-eminence to which the ancients attained in the fine arts, particularly in sculpture, statuary, and architecture, form an interesting subject for speculation. One obvious advantage of the *antique* imitation of the human form arose from the frequent opportunities which the artists enjoyed of viewing nature either entirely undraped or veiled only with light and graceful clothing. At the gymnasia, or public places where the youths performed the various feats of running, wrestling, boxing, and leaping, they had an opportunity of studying the finest examples of the natural and graceful play of the muscles, and had exhibited before them every variety of posture and attitude, with a dignity and expression which cannot now be obtained. Another essential advantage which the ancient works of art possess over modern productions is that they were generally works of much longer time. Among the ancients, it was thought a great deal for one sculptor to have executed four or five statues in the course of his life; hence the high finish of the most

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* See *Sir Joshua Reynold's notes upon Fresnoy.*

celebrated marbles of antiquity, which bears the minutest inspection, and the trial of every different light. It was likewise no small advantage to possess an unoccupied field, in which the exertions of genius were unfettered and free from the reproach of imitation. A modern artist labours under the disadvantage of a comparison with the fine models of antiquity, which, while he despairs of surpassing, he is compelled, by the tyranny of taste, in some measure to copy. Nothing can more cruelly damp the ardour of invention, or check the generous emulation to excel. We ought not, however, to allow our admiration of the antique to transport us too far, or to blind us to the faults which appear even in the statues of Greece and Rome, while we refuse a just tribute of applause to the exertions of our most esteemed modern artists. There is undoubtedly the greatest dignity and beauty in many specimens of the antique which we possess; but sometimes this is obtained at the expense of animation and just expression. "The ancient sculptors," says Sir Joshua Reynolds, "neglected to animate the features, even with the general expression of the passions. Of this, the group of boxers is a remarkable instance; they are engaged in the most animated action with the greatest serenity of countenance. This frequent deficiency, in ancient sculpture, could proceed from nothing but a habit of inattention to what was considered as comparatively immaterial."

It is said that Michael Angelo, desirous of exposing the undue predilection in which the classical antique was held in his time, formed with great care a statue of Cupid, which he buried in a spot where he was sure it would be found, after having broken off one of its arms. The Cupid having been dug up, all the world pronounced it to be an antique, and resounded with its praises; till the modern artist having produced the arm, which fitted exactly to the defective trunk, the connoisseurs were compelled, however reluctantly, to acknowledge their blunder. An intimate acquaintance with ancient sculpture and architecture implies something more than a skilful discrimination between what is truly beautiful and classical and what is fantastic or deformed. It implies, also, a knowledge of the different styles of the artists, the manners of the various ages, and the different kinds of materials on which the various arts have been practised, whether wood, clay, ivory, precious stones, marble, flint, or metal. The study of the antique has served to prove that the ancients had attained to wonderful skill in the arts of metallurgy, pottery, gem-engraving, founding, moulding, &c.; and in many respects seem rather to have excelled than to have fallen short of the most ingenious productions of the modern workshop. It was said by the late Mr. Wedgewood, who was doubtless the most skilful manufacturer of porcelain of modern times, that the celebrated Barberini vase afforded evidence of an art of pottery among the ancients, of which we are as yet ignorant even of the rudiments.

Some of the most beautiful works of modern sculpture have been employed to ornament the new palace in St. James's Park, as well as in the various public statues which have been erected in the squares of the metropolis; and it is gratifying to observe the growing taste which exists for blending architecture with the other branches of the fine arts. Our space will not however permit of our pursuing this matter further, and an estimate of the comparative degrees of excellence obtained by ancient and modern artists will be found under the articles FINE ARTS and SCULPTURE.

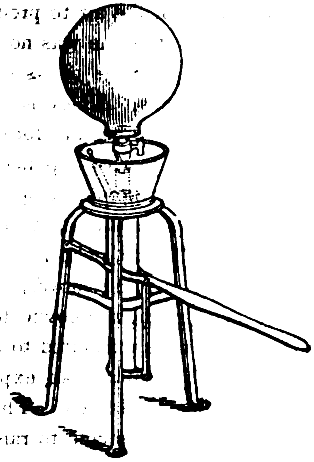
We may now proceed to trace the history of our acquaintance with the mechanical properties of the *air or atmosphere* which surrounds our globe. This is a very interesting branch of human knowledge, and as important to the chemical as to the pneumatic philosopher. Some of the properties of the air in which we live and breathe were well known to the ancient philosophers. Thus Aristotle says that all the elements have weight, with the exception of fire; adding that a bladder inflated with air will weigh more than when quite empty. Plutarch and Strobæus quote Aristotle as teaching that the weight of air is between that of fire and

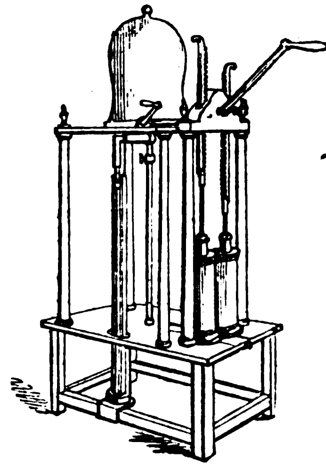
earth; and the latter philosopher himself quotes Empedocles as attributing the act of respiration to the pressure of the air, by which it insinuates itself into the lungs. Hero of Alexandria, in his work entitled *Spiritalia*, applies the principle of the elasticity of the air to produce and explain various effects, in such a way as sufficiently to convince us that he was no stranger to the properties of atmospheric air; and Ctesibius, adopting the principle of its elasticity, constructed wind-guns, which afterwards passed for modern inventions. There is, however, some difference between the ancient and modern air-guns. In that of Ctesibius, for example, the ball was not immediately exposed to the action of the air, but was impelled by the longer arm of a lever, while the air acted on the shorter; but the principle of operation is the same in both, and shows clearly that the elasticity of common air, if it could not be accurately measured, was at least well known at that period. Hero, who is now generally considered as the first who employed high-pressure steam as a prime mover, describes several ingenious pneumatic instruments. The effects which are now known to result from the weight and elasticity of the atmosphere were for a long time attributed to the imaginary principle of what was called "nature's abhorrence of a vacuum," an explanation which does not appear to have been called in question till the time of Galileo. This philosopher had studied the operation of a sucking-pump, which had been erected to raise water out of a cistern; and he was surprised to find that when the water descended to a certain point the pump ceased to act, and continued to lose its power by any further subsidence of the fluid. After reflecting for some time on this singular fact, Galileo attributed the rising of the water to the attraction between the piston and the fluid particles. Dr. Young says that "before Galileo's time, it was generally supposed that water was raised in a sucking-pump on account of the impossibility of the existence of a vacuum; if, however, a vacuum had been impossible in nature, the water would have followed the water to all heights, however great: but Galileo found that the limit of its ascent was about thirty-four feet, and concluded that a column of this height was the measure of the magnitude of the atmospheric pressure."

It occurred to Torricelli, in the year 1643, that, whatever might be the cause by which a column of water thirty-four feet high is sustained above its level, the same force would sustain a column of any other fluid which weighed as much as that column of water on the same base; and hence he concluded that, as quicksilver is about fourteen times as heavy as water, it could not be kept up at a greater height than twenty-nine or thirty inches. He then made the experiment still called after his name. He provided himself with a glass tube, about three feet long, and sealed it hermetically at one end, and, having filled it with mercury, he closed it at the open end with his finger, and inverted it in a basin of mercury. Upon withdrawing his finger, he had the satisfaction of seeing the column of mercury descend and settle at the height of between twenty-nine and thirty inches in the tube. He was still, however, not aware that the phenomenon was to be attributed to the pressure of the atmosphere, although after a little reflection he fell upon that explanation; and, after he had fully convinced himself of the truth of his hypothesis, it is said that, with a feeling of generosity of which we have few examples, he expressed his regret that it had not fallen to the lot of his master, Galileo, to have completed a discovery of which he had first laid the foundation.

The invention of the air-pump is the most important feature in the history of pneumatics, and Otto Guericke has justly been considered its first constructor; yet it was our own countryman Boyle who turned the instrument to useful purposes. In the hands of Otto Guericke the air-pump was a pleasing pneumatic toy: but in those of Boyle it became a valuable philosophical instrument. The value of modern mechanical improvements in this branch of science will, however, be best understood by graphic views of both pumps: the

first an accurate sketch of the apparatus as it was employed by Otto Guericke, and the other representing the improved apparatus as it is now constructed.





Otto Guericke formed a vacuum by fitting a piston in a barrel, which he immersed in a tub of water, and then raising the piston he formed an imperfect vacuum beneath it. In his subsequent experiments he placed the apparatus on a tripod stand, and discontinued the use of the water. It may be proper to state that motion was in the first instance given to the piston by a stirrup beneath. Now with this apparatus he performed many pleasing experiments, but never converted it to any really philosophical purposes.

The improved air-pump has two pistons made to fit accurately in brass barrels, and motion is given to them by a lever and two racks, so that when one is raised the other is depressed. By this beautiful mechanical arrangement the pressure of the atmosphere is equal in both barrels, and, when the pump is put in operation, a child's force will accomplish as much as could be effected by a strong man with the old apparatus.

The barometer is a pneumatic instrument which may certainly be said to date its history from the Torricellian experiment. Mariotte in France, and Boyle and Townley in England, found from experiment that the density of the atmosphere was proportional to the compressing weight; but this law is true only when the temperature of the air remains constant. Attention, however, was not then paid to this important restriction, which in fact could not be indicated by experiments where the compressed volumes of air differed but little from each other in respect to temperature. The law of compression being otherwise known, Halley made use of it for calculating the decrease of density in the beds of the atmosphere at different altitudes, and thus led to the mathematical formulæ by means of which the difference of altitude of two places may be calculated from the heights of mercury in the barometer observed at each of them. Newton, in his *Principia*, perfected Halley's theory, by showing that regard was to be paid to the diminution of gravity according as the distance from the surface of the earth increased. But, what is very remarkable in so scrupulous an observer of the laws of nature, he also, as well as Halley, omitted to consider the effect of the variations of heat, and of the progressive decrease of the temperature and density of the different strata of the atmosphere. The barometrical formulæ thus obtained, without the correction which renders them applicable to all temperatures, could only furnish a very imperfect approximation; and therefore philosophers and mathematicians who endeavoured to apply them found that they succeeded only in a few instances, and that generally the results seemed to be subject to various errors, which appeared to follow no uniform law.

M. de Luc discovered the true source of these anomalies, by searching in the observations themselves for the correspondence between the temperature of the air and the correction which the general formulæ required. Numerous experiments on the comparative expansions of air and mercury enabled him to perceive the law that those corrections ought to follow, and the quantity in all cases which should be assigned to them. This remarkable discovery, by giving to the barometrical formulæ an unexpected accuracy, animated the zeal of philosophers, and observations were multiplied to a great extent. Dr. Maskeleyne undertook to reduce the new formulæ into English measures, while Playfair added a correction to the variation of gravity in different latitudes. Sir George Shuckburgh, by very exact measures, verified the results of M, de Luc, and gave them a greater degree of precision. General Roy also made an application of it at a great number of places in the progress of his survey. The heights of the principal mountains in the Alpine chain were ascertained by M. M. Saussure and Pictet, the Pyrenees by M. Ramond, and the Andes by Humboldt. The barometer is now considered as valuable an instrument for measuring the heights of mountains as for foretelling the changes of the weather, and it is rendered so portable that a complete mountain barometer can be enclosed in a case very little larger than a common walking-stick.

The principles of the science of *acoustics* must be placed in connection with the subject we have now been discussing. The transmission of sound and the mechanism of audition were but little understood prior to the middle of the last century. Aristotle, deriving his information probably from the tenets of the Pythagorean school, seems to have formed tolerably just notions of the theory of harmonics. The language of that philosopher was so much corrupted, however, and disguised by ignorant transcribers, that Galileo, who not only studied music as a science, but practised it as a delightful art, may be fairly allowed to have rediscovered the general doctrines of harmony. Mersenne and Kircher afterwards made a variety of most ingenious experiments, which, though rather neglected at the time, tended greatly to extend the science. But it was reserved for the genius of Newton to sketch out the true theory of sound. In his *Principia* he illustrates the experiment of aërial pulses, and by a fine application of dynamics, conducted with his usual sagacity, he succeeded in calculating their celerity of transmission. The solution which he has given of this intricate problem is far, however, from being unexceptionable in the form and mode of reasoning. Instead of attempting to embrace all the conditions affecting the problem in a differential equation, for which, indeed, his fluxionary calculus was not yet far enough advanced, he proceeds less boldly, and only arrives at the conclusion by an indirect process and a sort of compensation of errors.

The velocity of sound was determined with considerable accuracy and on a great scale by Cassini and Maraldi, while employed in conducting the trigonometrical survey of France. During the winter of the years 1738 and 1739 these astronomers repeatedly discharged at night, when the air was calm and the temperature uniform, a small piece of ordnance from their station on Mont Martre, above Paris, and measured the time that elapsed between the flash and the report, as observed from a signal-tower at the distance of about eighteen miles. The mean of numerous trials gave 1130 feet in one second for the velocity of the transmission of sound.

About the same time Condamine, who was sent with the other academicians to ascertain the length of a degree in Peru, took an opportunity of likewise measuring the celerity of sound at two very different points. He found this was 1175 feet on the sultry plain of Cayenne, and only 1120 on the frozen heights of Quito. It was obvious therefore that the rarefaction of the air in those lofty regions had in no important degree affected the results. Compared with what had been observed in France, the velocity of the aërial pulses had

somewhat diminished at Quito by the prevailing cold, but was on the other hand considerably augmented by the excessive heat and moisture which oppress Cayenne.*

Mr. Goldingham, who made a series of experiments on the velocity of sound at Madras, considers that for each degree of the thermometer 1.2 foot may be allowed in the velocity of sound for a second, for each degree of the hygrometer 1.4 foot, and for one-tenth of an inch of the barometer 9.2 feet. He concludes that ten feet per second is the difference of the velocity of sound between a calm and in a moderate breeze, and twenty-one feet and a quarter in a second, or 1275 in a minute, is the difference when the wind is in the direction of the motion of the sound or opposed to it.

The process of hearing is certainly very remarkable, and well calculated to excite our surprise and curiosity, when we think of that infinite variety which we observe; single sounds, varying in intensity from the gentlest whisper to the noise and violence of an explosion; continued sounds, from the ripple of waters to the roar of the cataract; strains of melody which enchant the ear, rising from grave to acute, and falling again to the lowest in the compass; or those harsher notes which only grate in their discord. Can it be possible that all these diversities arise from the agitations in the air, differing only in the manner in which they strike the ear, in the force and quickness of their action, or in the regularity of their succession? What incredible sensibility in this organ, to perceive and be moved by such imperceptible shades of gradation, and to recognise such infinite diversities in kind! The powers of the eye in discriminating the minutest shades of colour justly excite our astonishment; but each colour presents a peculiar modification of light. The powers of the ear must appear still more extraordinary, if every sensation in it arises merely from a mechanical agitation of the same nature in every case, but only differing in the force of the impulse. Yet this is really the case; and the more we examine into the subject the more clearly does it appear demonstrable by the laws of geometry and mechanics.

That the air is the ordinary vehicle of sound is clearly proved by the beautiful experiment of enclosing a bell within the receiver of an air-pump, and then exhausting the air. As the process of exhaustion proceeds, the sound is observed to become continually fainter and fainter, until at last it dies away altogether. The bell, however, continues to ring: at least the hammer continues to strike, and thereby agitate the bell, as before; and yet no sound is emitted, plainly because there is no medium to convey the agitation to the ear. If the sound in this experiment cannot be altogether extinguished, this will be found to arise from the impracticability of exhausting the air altogether out of the receiver, and also of insulating completely the bell from the plate of the air-pump on which it stands, the support serving to convey the sound even after the air is exhausted. A very good mode of performing this experiment is to have a bell with a small piece of clock-work attached to it, which strikes at regular intervals, and with a tone of uniform intensity.

In order to conceive the mode in which sound is propagated through the air, let us consider what takes place when we move a series of balls ranged in a line on a table, or suspended

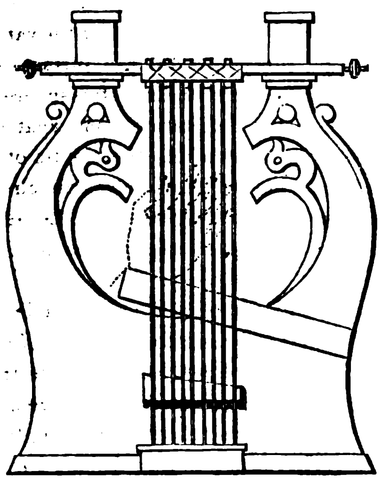
* The distance at which sounds may be heard is much greater than is generally imagined. Dr. Derham informs us, on the authority of S. Averrani, that at the siege of Messina the report of the guns was heard at Augusta and Syracuse, almost 100 Italian miles distant; and he also states that in the naval engagement between the English and the Dutch, which took place in 1672, the report of the guns was heard upwards of 200 miles off. Humboldt mentions the reports of volcanoes in South America heard at the distance of 300 miles; and Dr. Thomson states, on the authority of a friend, that the loud explosions which took place from the volcano in St. Vincent's were heard distinctly at Demerara: now this is a distance which must considerably exceed 300 miles. On the other hand, again, sound is enfeebled and dissipated sooner in alpine regions: thus, the traveller, roving at some height above a valley, descries with uncommon clearness perhaps a huntsman on the brow of the opposite mountain, and, while he watches every flash, yet can he scarcely hear the report of the fowling-piece.

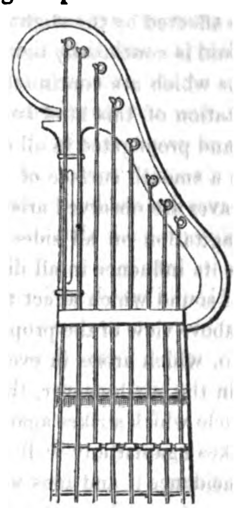
by threads. If we strike the one end of the line, by impelling a ball against it, it is only the ball at the other end which appears to be affected. This flies off from the rest, and leaves them almost stationary. The intermediate balls, therefore, serve merely to transmit the impulse from the one end to the other of the series. In the same manner it is that the agitation or impulse from which sound arises is transmitted through the air. This fluid, like every other body, consists of an almost infinite number of small particles, a single series of which may be represented to us by the balls in the above example. These particles are not even in contact with one another: they are separated by minute intervals, but are yet connected together by attractive and repulsive forces, which tend to retain them perpetually in equilibrio. In every case, therefore, there is in reality a series of such particles reaching from the sounding body to the ear. The former by its agitation strikes that particle which is next to it, the intermediate ones serve to convey the impression, and the last one, flying off, strikes the sentient organ of hearing. The ear then forms merely a sort of organ of touch, but of such exquisite sensibility that it becomes affected by the slightest agitation in the fluid atmosphere by which it is surrounded. But this fluid is continually agitated, and in a thousand different ways, by the various motions and actions which are continually going on among the bodies on the surface of the earth. Every agitation of this kind communicates itself to the surrounding atmosphere; it is by it conveyed and propagated in all directions from the centre of agitation, somewhat like what we observe in a smooth surface of wa terwhen a stone is thrown into the middle of it—a series of small waves are observed arising and propagating themselves in concentric circles from the centre of agitation on all sides. In a similar manner every agitation in the aërial medium propagates its influence in all directions, and from these varied impressions arise all those diversities of sound which affect the ear.

The above view of the propagation of sound explains at once the remarkable phenomenon of the echo, which arises in every case from obstacles opposing the progress of sound. The agitation in the air however, though interrupted by such obstacles, is not destroyed: each aërial particle which strikes against the opposing surface is reflected from it like an elastic ball which strikes against any wall or table. The sound is thus reflected at an angle equal to the angle of incidence; and it is when a number of these reflected impressions are thrown back to the point whence the original sound issues, by the configuration of the opposing obstacles, as so frequently happens among rocks, walls, &c., that an echo is produced.

The celebrated Chladni, whose loss will be deplored, not only in Germany, but by all who feel the importance of the study of the supreme law of nature by the analogy of its different elements, showed many years since that the vibrations of sounds put in motion grains of sand, united on a glass plate, in such a manner that when the tones are pure the grains unite in regular forms, and when they are discordant the grains trace upon the glass figures without symmetry. His latest discovery previous to his death was that of the manner of the propagation of sound, by means of applying the theory of liquid waves to that of aërial ones. When a sonorous bar of metal or glass is plunged into a liquid surface, four currents are observed round this bar, two of which are in the direction of the vibratory movement, and the others perpendicular to the direction of the former. Two currents are eccentric or flying, and two concentric or returning, and between them is formed an oval movement; and from these phenomena we may imagine what passes in the waves of the air, and explain the interruption of sound in certain directions where the waves take a compound course, viz. when they pass from the centrifugal to the centripetal movement. Nothing is so highly satisfactory as this analogy when shown to exist in different elements, an analogy which it has been the especial merit of the Germans, and of none more than Chladni, to inculcate as one of the fundamental principles to be borne in mind in the study of nature.

A very moderate acquaintance with the science of acoustics must have sufficed to enable the ancient musicians to construct their instruments, as they were usually of a very simple character, and as they rarely produced more than five or six different tones. The invention of the organ by Ctesibius forms a remarkable epoch in this branch of acoustical science. The larger wind instruments were furnished with hydraulic bellows, the smaller with bellows of leather only; and they had keys which were depressed, like those of the modern organs, by the fingers of the performer, and which opened valves communicating with the pipes. The early stringed instruments did not, however, make so rapid a progress, as the notes produced by the harp even in the last century were fixed and determined by a small number of cords attached to the sounding body. Exceptions did however occasionally occur to this rule, and we have even seen the sculptured remains of an early Grecian lyre in which an arrangement existed for changing the disposable length of the string. This was effected by a sliding bar, which might be moved by the musician during his performance.





This was a great step in the march of improvement, and an instrument of this description is carefully delineated in the above figure. But when we come to compare it with the instrument placed by its side we shall readily appreciate the value of modern improvement. In the harp-lute, or lyre, which forms the accompanying figure, there are only eight strings, and yet four-and-twenty distinct tones may be formed by the agency of small sliding levers; and, in the most perfect form of the harp, nearly 500 tones may be elicited by the same means. The apollonicon invented by Mr. Flight combines every other really valuable species of musical instrument within one range; and a series of vibrating metallic tongues have lately been combined so as to form a valuable wind instrument.

Hydrostatics may be said to date its origin from the time of Archimedes; he ascertained the laws which determine the weight of bodies immersed in fluids, and also the position which they would assume in floating on them. According to some authors, the work which Archimedes composed on hydrostatics we owe, as it now exists, to a translation from the Arabic; while others maintain that we have derived it from an immediate translation of the original Greek text. This work is divided into two books. The basis on which this author founds his theory is this: that every particle of a fluid being supposed equal, and equally heavy, will remain in the place in which it is found; or that the whole mass will remain in equilibrio when each particular particle is equally pressed in every direction. This equality of pressure, on which the state of equilibrium is made to depend, is demonstrated by experiment. The author afterwards examines the conditions which ought to obtain in order

that a solid homogeneous body, floating on a fluid, may take and preserve the situation of equilibrium: he shows that the centre of gravity of the body, and that of the body immersed, must be situated in the same vertical right line; that the weight of the body is equal to the portion of fluid displaced by it; that the body will be entirely immersed when its specific gravity is equal to, or exceeds, that of the fluid; and he also examines nearly all the other principles of the science of hydrostatics, which constitute the basis of our present knowledge on the subject. It appears, likewise, from his investigations, that two bodies of equal magnitude, both heavier than the fluid in which they are immersed, will lose equal parts of their weights; and that, reciprocally, when the weights lost in the same fluid are equal, the bodies are of equal magnitudes. The solution of the well-known problem of Archimedes, relative to the crown of Hiero, king of Syracuse, depends on the above principles. Besides the theoretical principles of hydrostatics, we owe also to this philosopher, according to some authors, an ingenious hydraulic machine, called from the name of its supposed inventor *the screw of Archimedes*. Diodorus asserts that this philosopher invented it in his voyage to Egypt, and that the natives of that country afterwards employed it for the purpose of draining the extensive marshes with which it abounds; but Vitruvius, a contemporary of Diodorus, does not enumerate it amongst the discoveries of Archimedes, of whom he was nevertheless a great admirer; and Claudius Perrault, the translator and commentator of Vitruvius, adds that the use Diodorus gives to this machine (namely, that it was employed to render Egypt habitable, by draining off the waters with which it was formerly inundated) makes it highly probable that the engine is of much earlier date than the time of the Syracusan philosopher.

The early philosophers believed that water was absolutely incompressible, and it was not till the middle of the seventeenth century that this doctrine was attempted to be controverted. The members of the Florentine academy tried the compression of water in three different ways, which are described in the account of their experiments printed in 1661. 1. Having provided two glass tubes, terminated by hollow balls, they filled the one partly, and the other to excess, with pure water, and joined the tubes hermetically, so as to form one piece. Then, applying heat to the first ball, till the water boiled, they forced its vapour to press against the column in the other stem. But no contraction of the fluid took place, though a copper ball was afterwards substituted; and, when the action of the heat was still further urged, the tube at last burst with violence. 2. Into a glass tube, immediately above six pounds of water, they introduced eighty pounds of quicksilver, without causing any diminution of volume. 3. Their most celebrated experiment was, having filled a hollow silver ball with water by a small hole, afterwards soldered accurately, to give it a few smart blows with a hammer, when, far from suffering compression, the water was seen to ooze or pass from the pores of the silver. Mr. Boyle, whose practice it was to repeat the more striking experiments made on the continent, had a round tin or pewter vessel filled carefully with water, and tightly plugged; the blow of a wooden mallet beat it flat; but, on piercing the tin with the point of a small nail, the confined water instantly sprang to the height of two or three feet. About the year 1752, Dr. Peter Shaw, who read public lectures in London, exhibited a strong copper ball of four inches in diameter, and filled with water by a small orifice, into which a screw was fitted, and forced to enter by turning an iron arm or lever: the globe was partly opened by this enormous squeeze, and the water spouted from the crevice as from a fountain. These experiments all concur to show that water is capable of sustaining an immense pressure without undergoing any very sensible contraction; but they prove, at the same time, the actual existence of such a contraction, since the projecting of the water, after a crack has once begun in the vessel that confines it, could only proceed from the evolution of an internal repulsive force.

The compressibility of water was first satisfactorily demonstrated by the ingenious Mr. Canton in 1762, by a very simple and conclusive experiment. To a glass ball, of rather more than an inch and a half in diameter, he joined hermetically a tube about four inches long, and having a bore equal to the hundredth part of an inch. The relative capacity of this ball, and of the stem, he ascertained by introducing mercury, and weighing nicely its separate portions. The stem was then marked by the edge of a file into divisions, corresponding each to the hundred-thousandth part of the whole capacity of the ball. This instrument was now filled with distilled water, carefully purified of its adhering air, and placed under the receiver of an air-pump: on producing an exhaustion, the water appeared instantly to swell, rising four divisions and three-fifths in the stem, or a space nearly equal to the mercurial expansion corresponding to half a degree of heat on Fahrenheit's scale. In a condensing engine, the water sunk just as much, for each additional pressure of an atmosphere,—the ball remaining always at the same temperature, or at the fiftieth degree of Fahrenheit. Since the stem was left open, the pressure exerted by the air, both on the inside and outside of the instrument, must in all cases have been precisely the same; and consequently the glass had no disposition to alter its figure and modify the results. The contraction or expansion produced was, therefore, confined wholly to the body of water and to the thin shell of glass, of which indeed the influence might be rejected as insignificant. It was hence decided that the purest water suffers a visible concentration, or a diminution of its volume, under a powerful compression. But, in the course of his experiments, Mr. Canton observed a curious circumstance, that water is more compressible in cold than in warm weather. Thus, the contraction, under a single incumbent atmosphere, amounted to 4.9 divisions when the thermometer stood at 34°, but was only 4.4 divisions when the heat rose to 64°. This singular fact might afford room for speculation; but it were better, in the mean while, to repeat the experiment again with more delicacy, and on a greater scale.

The compression of some other fluids was likewise measured in the same way. The contraction, under the weight of an atmosphere, and at the ordinary temperature, amounted, in millionth parts of the entire capacity of the ball, to sixty-six with alcohol, to forty-eight with olive oil, to forty with sea water, and only to three when mercury was employed.

In 1779, professor Zimmerman of Brunswick printed a short account of some trials made by him and Abich, director of the salt-mines, with a press of a particular construction, consisting of a water-tight cylinder of very thick brass, with a piston nicely fitted, to be pushed down by means of a long lever, at whose extremity different weights were appended. Rain-water being introduced into the cavity was subjected to an enormous pressure, equivalent to that of 313 atmospheres, and had its volume then diminished between one thirty-fifth and one thirty-sixth part. This quantity gives, for the effect of a single incumbent atmosphere, a condensation amounting to seventy-five millionth parts, instead of forty-six, as found by Mr. Canton. The excess was no doubt owing to the distention of the brass cylinder, which, with all its strength and solidity, would yet partially yield to the action of such a prodigious force. This circumstance renders the experiment somewhat unsatisfactory, and the influence of friction must likewise affect the accuracy of the calculation. The effect of such distention is easily witnessed in the case of glass. If a large bulb of a thermometer be suddenly squeezed between the finger and thumb, the mercury will start up in the stem perhaps several degrees, and will again sink as quickly after the pressure is removed. To prevent any derangement from communication of heat, the hand may be covered with a thick glove. But the fact can be shown in a less exceptionable way: let a mercurial thermometer, with a large bulb and a long stem, be first held upright, and then immediately inverted; between these two positions the column of mercury will descend through a visible space. This apparent change of volume has been hastily supposed by some

experimentalists to mark the compressibility of mercury, which could not be sensible but under the action of a column of incomparably greater height.

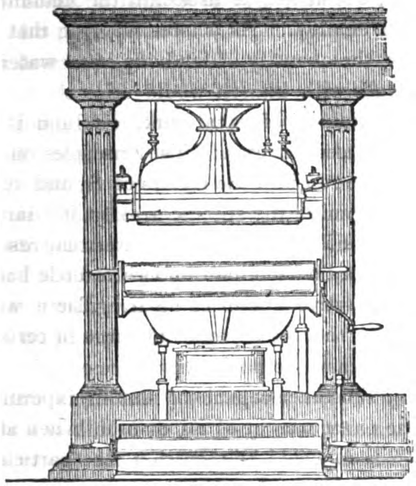
Mr. Perkins, a most ingenious mechanic, well known for the number and variety of his experiments, employed an instrument called a *piezometer*, to ascertain the amount of compression in different fluids. He subjected this instrument to a force equal to that of about 326 times the ordinary pressure of the atmosphere; and he found that the water it contained had been increased about three and a half per cent.

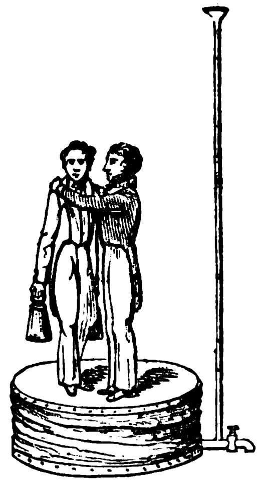
The clepsydra, or water-clock, acts upon purely hydrostatic principles; and it was employed as a means of measuring time at a very early period. The principles on which it should be constructed will be examined under the article HYDROSTATICS; and it may be enough to state that the French annals mention a curious water-clock, sent by Aaron, king of Persia, to Charlemagne, about the year 807, which, it would seem, bore some resemblance to the clocks now in use: it was of brass, and showed the hours by twelve little balls of the same metal, which at the end of each hour produced sounds from a bell. There were also figures of twelve cavaliers, which at the end of each hour came out through certain apertures, or windows, in the side of the clock, and shut them again.

The most obvious law of hydrostatics, and one on which nearly all our experiments are founded, is this, that the surface of every homogeneous gravitating fluid, when at rest, is horizontal. If any part of the surface were inclined to the horizon, the particles would necessarily tend towards its lowest part, in the same manner as if they moved without friction on the inclined surface of a solid. And if any two portions of the surface of the fluid be separated, as in two branches of a tube, or pipe, however they may be situated, the fluid cannot remain at rest unless the surfaces be in the same level plane; for, if we imagine such a tube, containing water, to be made of ice, and to be immersed in a large reservoir of water, and then thawed, the water will make a part of the general contents of the reservoir: and it is obvious that the tube has acquired no new power of supporting it by being thawed: consequently the water would remain in a state of equilibrium at the same height in the tube. The experimental proof of this proposition is easy and obvious, and the property affords one of the most usual modes of determining a horizontal surface. But, when we compare the heights of fluids occupying tubes of different magnitudes, it is necessary, if the tubes are small, to apply a slight correction on account of the actions of the tubes on the fluids which they contain, which are more apparent as their diameters are smaller. There is a very singular paradoxical experiment illustrative of this part of our subject. It is this, that any quantity of water, or any other fluid, however small, may be made to balance and support any quantity, or any weight, how great soever. Thus, water in a bent pipe, or canal, open at both ends, always rises to the same height at both ends, whether those ends be wide or narrow, equal or unequal. And since the pressure of fluids is directly as their perpendicular heights, without any regard to their quantities, it follows that whatever the figure or size of the vessels may be, provided their heights be equal, and the areas of their bottoms equal, the pressures of equal heights of water are equal on the bottoms of those vessels, even though the one should contain a thousand, or even ten thousand times as much as the other.

When a machine is constructed expressly for the purpose of showing, in the most striking manner, that the pressure of fluids is as their perpendicular heights, and that a quantity, however small, may be made to support a weight or another quantity however large, it may be most advantageously made by the apparatus called the hydrostatic bellows. This ingenious machine was much employed by the early experimentalists, under the name of the *paradoxical instrument;* it was however in truth rather employed to excite the admiration of the vulgar than to elucidate the principles of hydrostatical science. The bellows are shown

in operation in the subjoined figure; two or three persons may readily be placed on a small pair of bellows and actually elevated by a few ounces of water.





To illustrate this singular experiment, we may suppose a hole to be made in the upper part of the board, and another tube to be inserted there; the water would certainly rise to the same level in them both; and, supposing the board to be filled with tubes, the water would attain the same level in them all, because a series of pipes would, in fact, form a solid cylinder of water. If we suppose the hole to be of the same diameter as the interior of the tube, and fitted with a piston, then, if the tube contained two ounces of water, the piston would sustain a weight of two ounces without being depressed. If the area of the hole were twice that of the bore of the tube, two ounces in the tube would sustain four ounces on the piston. In this manner, every part equal to the bore of the tube is pressed upwards with a force equal to the weight of fluid in the tube. Hence, if the proportion subsisting between the area of the tube and that of the bellows be multiplied by the weight of water in the tube, the product will express the force with which the boards are separated.

Turning from this very demonstrative scientific toy to the practical application of the principle it exhibits, in the useful arts, we may refer to the machine placed in juxta-position to the "paradoxical instrument." This exhibits a combination of powers surpassing that of any other simple hydrostatic apparatus. A pressure equal to fifty or sixty tons may readily be put in operation by a single labourer. We are indebted to Mr. Bramah for the invention of this press, and, in the case before us, it is applied to the dyeing and pressing of linen. In this apparatus, Mr. Bramah suggested the use of a very strong metal cylinder, in lieu of the bellows part of the apparatus, the leather of which would be incapable of resisting any very considerable pressure. A piston or plug was so arranged as to move water-tight in the cylinder; and, as a substitute for the high fluid column, he employed a small forcing-pump for raising the water, and thus the pressing column becomes indefinitely long, although the whole apparatus is of itself comparatively small. Taken as a whole, Bramah's press may be considered as one of the most important discoveries in modern times.

That branch of the science of hydrostatics which relates to the *specific gravity* of bodies may be said to date its origin from the time of Archimedes. Hiero, king of Syracuse, is said to have employed an artist to make him a regal crown of gold, and furnished a sufficient quantity of pure metal for that purpose. When the crown was finished, its weight was found to equal that of the gold delivered for it; yet the king suspected an adulteration, and,

vapour is generated by the application of a lamp placed beneath. As the steam ascends from the cauldron it enters the ball by the hollow axes, and ultimately rushes from the two small apertures exhibited in the engraving. From this it will be seen that the action of Hero's steam apparatus must be precisely similar to that of the rocket-wheel, only high-pressure steam is substituted for inflamed gunpowder.*

Without tracing the various steps by which this "potent commander of the elements,—this abridger of time and space," has acquired its present high degree of perfection, it may be enough in the present place to state that we are mainly indebted to the celebrated James Watt for those improvements by which it has become a patient drudge in every branch of our manufactures, and served the cause of humanity most effectually by substituting inanimate power for muscular exertion.

The use of water as an impelling power, both for the turning of machinery and other purposes connected with the useful arts, appears to have been known at a very early period. Vitruvius describes a variety of machines for this purpose, the earliest of which were employed merely to raise a portion of the fluid by which they were impelled. The most simple method of applying this element as a mechanical agent evidently consisted in the construction of a wheel, the periphery of which was composed of float-boards. This, on being exposed to the action of a running stream, was afterwards employed to give motion to a variety of mills. But few improvements have been effected in the construction of these machines; and, though we now apply their powers to a greater variety of purposes, they are yet in point of principle nearly identical with those employed in the time of Vitruvius.†

Sextus Julius Frontinus, who was inspector of the public fountains at Rome, published a valuable work on the conveyance of water by aqueducts; he describes those which the Romans had constructed, and the dates of their erection. He then fixes and compares with each other the measures of capacity which he employed at Rome for ascertaining the products of the ajutages. On these subjects he made several correct observations: thus, for example, he showed that the quantity of water issuing from an ajutage did not wholly depend upon its magnitude, but that the height of the reservoir above it must also be considered. He showed also that the tube designed to carry off part of the water of an aqueduct ought to have,

* At first view, the power of Hero's apparatus would appear exceedingly small; but the editor has a model which he employs in his public lectures which is nearly as powerful as a small high-pressure engine of the same size.

† A distinguished French writer on hydrodynamics, when speaking of these monuments of human genius, asks, "to whom do we owe all these useful and important discoveries? What honours, what recompenses, have these benefactors of man received of their country or the world at large? History commonly answers nothing to these enquiries; while great pains are taken to transmit the names and exploits of conquerors who have ravaged the earth and left traces of misery and destruction in all their steps." These observations of Bossut apply pretty generally to every age of scientific discovery; and it is but justice to the government of Napoleon Buonaparte to remark that he set the example of bestowing honours and dignities on those most celebrated for their scientific eminence. We have somewhat tardily followed in the march of justice to these best benefactors of mankind, and the present century has to record the names of Davy, Herschel, Brewster, and Bell, as instances of men whose services have received the meed of their country's praise, and obtained its well-earned honorary distinctions.

permanent than those which have undergone that process. A remarkably good red ink is obtained as follows:—A quarter of a pound of the best logwood is boiled with an ounce of pounded alum, and the same quantity of cream of tartar, with half the quantity of water, and, while the preparation is still warm, sugar and good gum-Arabic, of each one ounce, are dissolved in it. Solutions of indigo with pieces of alumina, and mixed with gum, form a blue ink. Green ink is obtained from verdigris, distilled with vinegar and mixed with a little gum. Saffron, alum, and gum-water, form a yellow. It is not well ascertained how soon the present kind of writing-ink came into use. It has certainly been employed for many centuries in most European countries; but the ancient Roman inks were, for the most part, of a totally different composition, being made of some vegetable carbonaceous matter, like lamp-black, diffused in a liquor. Sometimes the ink of very old writings is so much faded by time as to be illegible. Doctor Blagden (*Philosophical Transactions*, vol. 77) in his experiments on this subject, found that, in most of these, the colour might be restored, or rather a new body of colour given, by pencilling them over with a solution of prussiate of potash, and then with a dilute acid, either sulphuric or muriatic; or else, *vice versâ*, first with the acid, and then with the prussiate.

INLAND NAVIGATION. A general account of CANAL NAVIGATION has already been given under that head; and a view of river navigation will appear under RIVERS. We now purpose giving a general view of the canals in Canada. Those of the United States of America will be noticed in their several geographical divisions, as they are too numerous to be brought into one article.

Welland Canal was constructed between the years 1824 and 1829. Its length is forty-one miles and a half; its breadth at the surface fifty-eight feet, at the bottom twenty-six feet, and its depth eight feet. This line of navigation passes from the mouth of Ouse River, on Lake Erie, north-eastward, to strike at a point of the Welland or Chippewa River; and, taking the course of that river, downwards, eleven miles, proceeds thence northward, across the mountain ridge, and down to the mouth of Twelve-Mile Creek, on Lake Ontario. The distance from lake to lake is forty-three miles. The deepest cutting, near the summit, is fifty-six feet. It has thirty-five locks, one hundred to one hundred and twenty-five feet long, twenty-two to thirty-two feet wide. The capital stock of the company is 200,000*l.*; the number of shares 16,000. This canal admits of sloop navigation, and opens a communication between Lake Erie and Lake Ontario in the same vessels, which are thus enabled to navigate those lakes without discharging and reloading cargoes. One of the purposes of its construction was, to prevent the trade of that part of Upper Canada which communicates with the great western lakes from being diverted to New York, by the route of the Erie Canal. It was an arduous and stupendous work, as appears sufficiently from the dimensions and length of the canal. Its execution was, however, facilitated by taking advantage of natural channels of slack-water.

La Chine Canal is ten miles in length, from Montreal, on the St. Lawrence, directly to Upper La Chine, on Lake St. Louis, cutting off a bend in the river, and avoiding the rapids of St. Louis. Cost, 220,000*l.*; for sloop navigation.

L'Isle Perrault Canal is a projected work of five miles in length, from St. Louis Lake, at the foot of St. Anne's rapids, to the head thereof, by a canal, passing either at the back of St. Anne's or else across the Isle Perrault.

Grenville Canal is a projected work of twelve miles in length, from the head of Long Sault, or Ottawa falls, at the village of Grenville, by a lateral canal to the foot of Carillon rapids, opposite Point Fortune; for sloop navigation. Estimated cost, 250,000*l.*

La Petite Nation Canal is a projected artificial channel of navigation, of fifty miles in length, from the foot of Carillon rapids, at Hawkesbury, on the Ottawa, across the peninsula, to the St. Lawrence, at Prescott.

The *Rideau Canal*, which is now just completed, is described, and a view of its locks given, under the cut CANADA, in the Second Division of this work.

INSTRUMENT, in *music;* any sonorous body, artificially constructed for the production of musical sound. Musical instruments are divided into three kinds—wind-instruments, stringed instruments, and instruments of percussion. Of the stringed instruments among the ancients, the most known are the lyre, psalterium, and trigonium; the principal wind-instruments are the tibia, fistula, tuba, cornu, and lituus; those of percussion, the tympanum, cymbalum, and crepitaculum.

INSTRUMENTAL MUSIC; music produced by *instruments*, as contradistinguished from vocal music. The term *instrumental* is particularly applied to the greater compositions, in which the human voice has no part. The first instrument invented was probably the pipe or flute. An idle shepherd might very naturally, from accident, or in imitation of the effects of the wind, blow through a simple reed, and thus invent the pipe, from which the flute would readily originate. The pipe is, in fact, found among many savages. The invention of stringed instruments, as they are more artificial, is of later origin. The instrumental music of the Greeks was confined to a few instruments, among which the flute, the cithara, the sackbut, though not precisely like those instruments among the moderns, were the most important. The violin was invented in the middle ages, and soon became the principal instrument, taking place above the flute, though the latter is of much more ancient origin, because the playing on a stringed instrument is less fatiguing, and the tone of the violin is more distinct from the human voice, and therefore better fitted to be used with it; besides, the instrument permits much more perfect execution. Until the middle of the last century, the Italian composers used no other instruments in their great pieces than violins and bass-viols; at that time, however, they began to use the hautboy and the horn; but the flute has never been much esteemed in Italy, particularly in music exclusively instrumental. These were the only wind-instruments in Italy, used in instrumental music, until the end of the last century; and even to this day the Italians use wind-instruments much less than the Germans, and particularly the French. Since Mozart, every instrument has been used which appeared adapted to answer a particular purpose. This is the cause of the fewness of the notes in the Italian, and of their great number in German, and their excess in the modern French scores. In general, symphonies and overtures, solos, duets, terzettos, quartettos, quintettos, &c., sonatas, fantasias, con-

cerios for single instruments, dances, marches, &c., belong to instrumental music.

INSURANCE is a contract whereby, for a stipulated consideration, called a *premium*, one party undertakes to indemnify another against certain risks. The party undertaking to make the indemnity is called the *insurer* or *underwriter*, and the one to be indemnified the *assured* or *insured*. The instrument by which the contract is made is denominated a *policy;* the events or causes of loss insured against, *risks* or *perils*; and the thing insured, the *subject* or *insurable interest*. *Marine* insurance relates to property and risks at sea; insurance of property on shore against fire is called *fire* insurance; and the written contracts, in such cases, are often denominated *fire* policies.

There was a kind of insurance in use among the Greeks and Romans, called *bottomry* or *respondentia*, which is where the owner of a vessel or goods borrows money upon bottomry, upon the vessel, or upon respondentia on the goods, for a certain voyage, agreeing that, if the ship or goods arrive at a certain port, the money shall be repaid, and also interest, exceeding the legal rate; but, if lost by the risks specified in the bond before arriving at the port named, the lender is to lose the money loaned. This risk of losing the whole capital is the cause of the excess of interest allowed in case of the arrival of the ship or goods; and it is called *marine interest*, which ought to be equal to the common rate of interest added to the rate of premium for insuring the ship or goods for the same voyage against the same risks. This sort of contract was anciently in use, and, as the laws then gave less security, or, at least, as credit and confidence were not so widely diffused, and correspondence was less extensive among merchants, it was usual for the lender to send some person with the property, to receive repayment of the money loaned and the marine interest, at the port where the risk terminated. In modern times, it is not usual to send any person with the property, who would not be of service during the voyage; and, at its termination, some agent of the lender, at the port of arrival, if he is not there himself, looks after his interest.

The wide extension of correspondence, among merchants in all parts of the world, in modern times, gives a facility for this purpose, and renders the execution of this, as well as other commercial contracts, more economical, and at the same time more secure. But contracts of insurance, strictly so called, are of modern invention; and their importance, in relation to commerce, is scarcely inferior to that of bills of exchange. Every merchant is liable to losses and reverses, by the change of the markets. The risks of this description may, however, be calculated upon with some degree of probability; but those of fire, the perils of the seas, or capture, cannot be so well estimated; and, when they come, they would, in many cases, bring ruin upon the merchant, if it were not for the system of insurance, the object of which is to apportion the losses from these disasters among all those whose property is exposed to the same hazards. If, for instance, all persons engaged in trading were to enter into a general agreement to contribute for the losses of each other, occasioned by those casualties, in the proportions of the amounts that they should respectively have at risk, every individual would then only run the risk of the proportion of losses occurring upon the general aggregate of property at risk. But as such a general combination would be complicated, and practically inconvenient, a very simple system is devised, by means of insurance, for effecting the same object; for one person—the underwriter—agrees to take upon himself those risks for a hundred merchants, more or less, for a certain premium on each risk, calculating that the premiums on the fortunate adventurers will compensate him for the losses he may incur on those which are unfortunate, and leave him some surplus, as a compensation for his time and trouble; and a little experience will enable him to calculate the chances with very considerable accuracy. The result accordingly is, that all the persons who procure their property to be insured by him, in effect, mutually contribute for each other's losses, by the bargain of each with the common receiver of the contributions of all. This contract was subjected to a system of definite rules much earlier in Italy and France than in England; and, as the contract is the same in principle and very similar in form in different countries, the rules of construction adapted to it in one country are equally applicable in another.

Insurances on human life may now be noticed. The duration of life, over which the most healthy and the most temperate man has no certain control, must necessarily appear a matter of chance when individually considered. If, however, we regard the human species in masses, we are enabled to ascertain with considerable precision the average of life; and thus to apply a system of insurance, not to life itself, for that is, of course, dependent upon a higher power than man, but against the injurious consequences which proceed from the death of those upon whom the support of others depends. If we take ten millions of people, for instance, and ascertain the age to which each person arrived previously to his death, by dividing the total of their ages by the number of individuals, we establish the average term of the duration of life. This term varies in particular countries and under different states of society; but it is invariably found to increase with the increase of the means of comfort. The average term of life in Great Britain is thus longer, by almost one-third, than it was during the last century. The rate of mortality in 1780 was one in forty; in 1821 it was one in fifty-eight. Vaccination, and the great improvements in medical science, have doubtless contributed to this result. To establish data for determining this mean length of life has been an important object with statesmen, of late years, and forms a great branch of the science of statistics. The tables which have been constructed upon the experience of most European nations enable us, not only to determine the average term of life, but the probabilities of the number of years a person of any particular age has to live. Upon these calculations is founded the system of life-assurances and annuities; and the various corporations which grant life-assurances are enabled to conduct their operations upon a just and solid foundation, in proportion as they form their estimates upon averages equally supported by science and experience. To all persons whose income is not permanent, and who are unable to lay by a sufficiency to prevent the lamentable consequences to their children of an inadequate provision, the principle of life-assurance offers a safe and effectual remedy against the chances of mortality, which no prudent father should forego, if the annual sacrifice

sides, so that the liquid portion filtrates through it slowly, and water is occasionally added, as the filtration proceeds, until a quantity of liquid has passed through ten times the weight of the sub-carbonate of potash employed. The lime in this process attracts the carbonic acid, and from the large quantity employed, and the slowness with which the water holding the alkali dissolved passes through it, the abstraction is more complete than could be obtained by any other simple arrangement.

Though the potash obtained by this process is nearly pure, it is not perfectly so; a little carbonic acid remains combined with it, and there may also be present small portions of sulphate and muriate of potash, and silicious earths. To obtain it in a state of purity, different methods have been proposed; that which is generally followed is one proposed by Berthollet. Potash is soluble in alcohol, but is insoluble when combined with carbonic or sulphuric acid. The alkaline solution, therefore, obtained by slow filtration from the mixture of sub-carbonate of potash and lime, is evaporated until it becomes of a thick consistence, and there is then added to it an equal weight of alcohol. A quantity of undissolved matter subsides; a dark-coloured liquid floats above this, which is principally water holding dissolved potash combined with carbonic acid; a lighter coloured liquor is above this; it is drawn off, and is partially evaporated in a silver bason. On standing, it separates into two liquids of different specific gravities, the heavier being a solution of the alkali with carbonic acid, the lighter a solution of pure alkali. The latter is poured off, and is evaporated, so that on cooling it shall either deposit crystals or pass into an irregular crystallized mass; a small portion of residual liquor being poured off, the potash is thus obtained in a solid form. Potash thus prepared is obtained by evaporation in a solid mass, hard, and brittle, of a grayish-white colour. If evaporated to a less extent, it crystallizes in forms which are modified by the degree of evaporation; it is thus obtained in thin plates, in slender needles, or in tetrahedral pyramids, single or double, these containing different portions of water of crystallization.

Potash is an alkali of considerable strength: a minute portion of it changes the blue and purple colours of vegetables to a green, and it is so powerfully corrosive as quickly to erode and dissolve animal matter. It unites with oils and fats, forming soaps, which, though concrete, are soft and gelatinous. See Soap.

It is under the form of sub-carbonate of potash that this salt is afforded in the processes by which it is usually obtained, as in the incineration of the wood of plants. It therefore forms the base of the potash or pearl-ash of commerce, which also contains, however, other saline substances, particularly sulphate and muriate of potash, and earthy and metallic matter. From these it is in part freed, by dissolving the pearl-ash in an equal weight of warm water; the foreign substances, being sparingly soluble, remain in a great measure undissolved; the clear liquor is poured off, and is evaporated until a pellicle appears on its surface; on cooling and remaining at rest for a few hours, it deposits a little muriate of potash, and, being poured off from this and evaporated, the sub-carbonate is obtained.

The process for obtaining pot and pearl-ash is given by Kirwan as follows:

1. The weeds should be cut just before they seed, then spread, well dried, and gathered clean.

2. They should be burned within doors on a grate, and the ashes laid in a chest as fast as they are produced. If any charcoal be visible, it should be picked out, and thrown back into the fire. If the weeds be moist, much coal will be found. A close smothered fire, which has been recommended by some, is very prejudicial.

3. They should be lixiviated with twelve times their weight of boiling water. A drop of the solution of corrosive sublimate will immediately discover when the water ceases to take up any more alkali. The earthy matter that remains is said to be a good manure for clayey soils.

4. The ley thus formed should be evaporated to dryness in iron pans. Two or three at least of these should be used, and the ley, as fast as it is concreted, passed from the one to the other. Thus, much time is saved, as weak leys evaporate more quickly than the stronger. The salt thus produced is of a dark colour, and contains much extractive matter, and, being formed in iron pots, is called potash.

5. This salt should then be carried to a reverberatory furnace, in which the extractive matter is burnt off, and much of the water dissipated: hence it generally loses from ten to fifteen per cent of its weight. Particular care should be taken to prevent its melting, as the extractive matter would not then be perfectly consumed.

The commercial value of this important alkaline body may now be examined. Potash differs considerably from pearl-ash in its value. The best Russian potash, as it is imported into this country, is in large lumps, as hard as a stone, and black as a coal, incrusted over with a white salt, that appears in separate spots here and there in it. It has a strong, fetid, sulphurous smell, as well as a bitter and lixivial taste, which is rather more pungent than other common lixivial salts. A lixivium of it is of a dark green colour, with a sulphurous smell and bitter taste, but more like a simple lixivium. Though it is as hard as a stone when kept in a close place, or in large quantities together in a hogshead, yet, when laid in the open air, it turns soft, and some pieces of it run into a liquid. It readily dissolves in warm water, but leaves a considerable sediment, of a blackish-gray colour, like ashes, which is in a fine soft powder, without any dirt or coals in it, as observed in most other kinds of potash or kelp. As it is dissolving in water, there rise from it some lumps of a dark purple bituminous substance, like petroleum or tar, which readily dissolves in the lixivium.

According to M. Vauquelin, two ounces of various kinds of potash contained as follows:

The pearl-ashes from Russia contained 772 grains of potash, combined with 254 of carbonic acid and water, sixty-five of sulphate of potash, five of common salt, and fifty-six of indissolvable matter.

Dantzic contained 603 grains of potash combined with 304 of carbonic acid and water, 152 of sulphate of potash, fourteen of common salt, and seventy-nine of indissolvable matter.

That from Treves contained 720 grains of potash, combined with 199 of carbonic acid and water, 165 of sulphate of potash, forty-four of common salt, and twenty-four of indissolvable matter.

That from Vosges contained 444 grains of potash in combination with only sixteen of carbonic acid

years; and there are antiquarians who date its production several centuries before the Christian era; since, as has been said, sculpture was declining in excellence in the time of Alexander the Great.

PORTRAITURE. In the article PAINTING we have given a full account of that interesting branch of portraiture which relates to miniature subjects, and the mode of blending colours in oil-painting is adverted to under the same head. The art of delineating the human form is probably as old or older than any other branch of the fine arts. Indeed we are told that the maid of Corinth who traced the outline of her lover, by the shade of a secret lamp, confined herself to delineating his portrait, and this species of outline has since been revived under the name silhouettes. The next step was the monogram, consisting of outlines of figures without light or shade, but with some additions to the parts within the outline. This was speedily followed by ENCAUSTIC PAINTING, described under that article. Portraiture appears to have advanced but very slowly till the time of Apelles, when we find that distinguished artist highly extolled for the accuracy of his likenesses. His portrait of Alexander, placed in the temple of Diana, was considered his masterpiece; and we are told that the mimic lightning he represented appeared about to dart from the picture. Without, however, tracing portraiture through all its stages, it may be enough to say that it attained a high degree of perfection, but to fall in the common wreck of every thing that was refined or valuable in civilized life. In those dark ages which succeeded portraiture made but little progress. It was considered as a very humble branch of the fine arts, and the best painters were engaged in devotional works which required but little skill in accurate portraiture. This remark applies especially to the great recoverers of art, Cimabue, Giotto, Masaccio, Luca, Signorelli, and Leonardo da Vinci. The latter, who was an excellent anatomist, made considerable progress in portraiture.

The terrible sublimity of Michael Angelo has already been illustrated in our history of the fine arts; and his human figures, though they rose from his canvas a race of giants, were still powerful though exaggerated portraits of the human form. Raffaelle humanized portraiture, and threw his own benignant spirit into the features he created. Perfect human beauty he has not represented; but there is a mildness and perfection of keeping in his pictures which raise them very high in the standard of art. The harmony and grace of Correggio was alone wanting to complete the portraiture of the period. But we must hasten by the names of Giulio, Romano, Titian, Caracci, Domenichino, and the other great masters who succeeded to them, and pass at once to the progress of portraiture in our own country.

Holbein and Zuccheri were the earliest portrait painters patronized in this country. The first Charles employed Rubens to paint several large works, and liberally patronized the prince of portrait painters, Vandyke. The English court also gave full employment to the pencils of Sir Peter Lely and Sir Godfrey Kneller. The comparatively humble names of Dobson, Riley, Cooper, Greenhill, Jervas, Richardson, Hayman, and Hogarth, bring us down to a better era.

Sir Joshua Reynolds remodeled the school of portrait painting, which was also much indebted to the accurate delineations of Romney, Opie, and Barry; but it is to the late president of the Royal Academy that we must look for the highest degree of excellence in the art. He created a school from which we are now deriving a degree of benefit without a parallel; and, did our space permit us to speak of contemporary artists, we might point out the good effects of his style as exhibited in the first names of the present day.

We have seen that portraiture commenced with a simple outline, formed by a shadow that was afterwards filled in by a series of tints, which tended to give rotundity and form to the whole. The present mode of effecting this is by the use of a species of lever, of which the axis is movable, and one extremity forms the delineator, while the other is made to pass over the face. Now it will be obvious that, if the arms are equal, the portrait will be the size of the original; but if, on the contrary, the tracing arm be larger than the one which holds the pencil, then the portrait will be but a miniature representation. A nearly similar but still more ingenious apparatus for portraiture has been contrived by Mr. Ronalds. It is described under PERSPECTIVE INSTRUMENTS; and any person possessing that simple apparatus may readily take portraits, with the connecting adjuncts, of any required size, the size being determined by the relative situation of the drawing-paper, and the object to be drawn, from the eye.

The sculptor transfers his portraits from the wax model by a mechanical apparatus very similar to that which we have already described as fitted for the human profile, and dots off on his block of marble the precise points from which the material is to be cut in delineating the portrait.

POTASH. This valuable alkaline body is generally known in commerce under the name of potash, or the vegetable alkali. It is usually procured from the combustion of land vegetables, the process being carried on in those countries which abound in wood. The ashes remaining after the combustion being lixiviated, the liquor affords, on evaporation, saline matter, which, when exposed to heat, forms a solid white mass. This consists of various salts, principally of potash, combined with carbonic acid, partly also of potash combined with sulphuric and muriatic acids, together with silicious earth, oxides of iron and manganese, and occasionally other impurities. The alkaline matter is obtained in different quantities from different vegetables: the harder woods afford more than those that are spongy, shrubs more than trees, herbaceous plants a quantity still larger, and even different parts of the same plant give different proportions of it, the leaves from a given weight yielding more than the branches, and the branches more than the trunk.

Potash is sometimes procured from other sources, and in a state more pure, as from the decomposition by heat of the salt named tartar, or the deflagration of nitre with charcoal, this alkali being the base of these salts. Potash, as obtained by all these processes, is combined with carbonic acid. To abstract this, the saline matter, the subcarbonate of potash, as it is named, is first freed from the other ingredients by lixiviation and evaporation of its solution, and is then mixed with twice its weight of recently slaked lime, and as much water as is necessary to give the consistence of a thin paste: this is put into a glass funnel, the tube of which is obstructed with a piece of linen; the mass of lime soon sub-

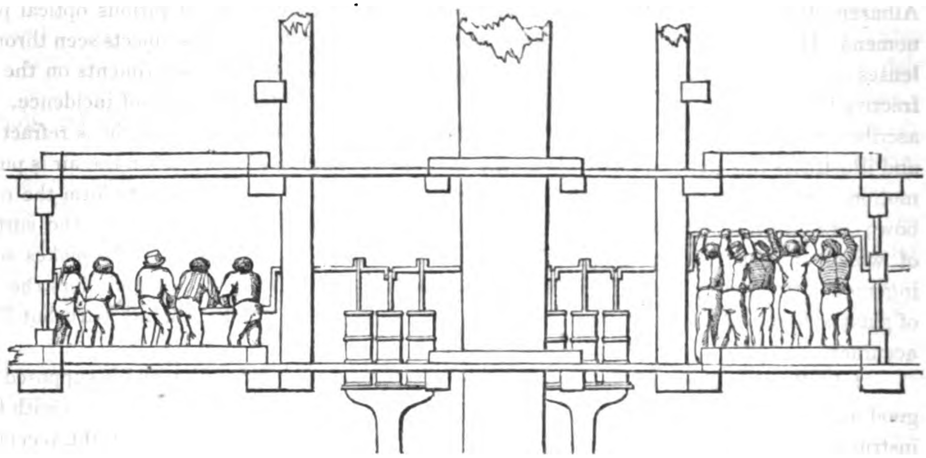
according to circumstances, a position more or less oblique with respect to the course of the stream. From the time of Frontinus to that of Torricelli but little progress was made in our knowledge of the motion of fluids. This eminent mechanic was for some time the contemporary of Galileo. He ascertained the velocity with which water issues from an aperture in the side or bottom of a vessel, and showed that it must be the same velocity which a body would acquire by falling from the level of the surface to the level of the orifice. This proposition, now so well known as the basis of the whole doctrine of hydraulics, was first published by Torricelli at the end of his treatise entitled *De Motu Gravium et Projectorum.*

The beginning of modern experimental improvements in hydraulics may perhaps be dated from the investigations of Smeaton respecting the efforts of wind and water, which were published in the *Philosophical Transactions* for 1759. His observations are of material importance, as far as they are capable of immediate application to practice, but he has done little to illustrate their connection with the general principles of mechanics. M. Borda first derived from a just theory the same results respecting the effects of undershot water-wheels as Smeaton obtained from his experiments about ten years after. Before this time, the best essay on the subject of water-wheels was that by Helvius, published in 1742: his calculations are accurate, but they are founded in a great measure on the imperfect suppositions respecting the impulse of a stream of water which were then generally adopted.

We have already seen that the ancients ascribed the rise of water in pumps to nature's abhorrence of a vacuum, so that the simple operation of the air's pressure was converted into an occult quality. This was the belief even as late as the time of Galileo, who inferred from some of his experiments that nature's abhorrence of a vacuum only extended to between thirty and forty feet. Thus, then, we find that so late as the seventeenth century the science of one of the most distinguished philosophers of the period consisted in transferring from the moral to the physical world the ideas of affection and hatred. The very obvious effect of the pressure of the atmosphere, forcing the water into the vacuous space in the pump-barrel, does not appear to have been understood till the weight of the air had been measured; and the height of the column of water, elevated by a good sucking-pump, is now known to vary with the density of the medium in which it is placed. The force required to work a pump will be as the height to which the water is raised, and as the square of the diameter of the pump-bore in that part where the piston works; so that if two pumps be of equal heights, and one of them be twice as wide in the bore as the other, the wider will raise four times as much water as the narrowest, and will therefore require four times as much strength to work it. The wideness or narrowness of the pump, in any part but that in which the piston works, does not make the pump either more or less difficult to work, except what difference may arise from the friction of the water in the tube, which is always greater in a narrow bore than a wide one, because of the great velocity of the water.

The pump now employed consists, as in the time of Ctesibius, of a barrel furnished with a piston made to fit air-tight. On the elevation of this plug, it will be obvious that a vacuum must be formed beneath; and the perfection of the pump will depend upon the accuracy with which the piston is fitted. The old pumps, by admitting air round the piston, very much impaired their value as hydraulic machines; and in many cases, instead of raising the water between thirty and forty feet, they could scarcely be made to operate till the water had been "fetched" by the assistance of the same fluid poured from above. In other cases the suction-pipe is, even in the present day, frequently so disproportioned to the pump-barrel, that more than a third of the power is lost by the undue velocity given to the ascending column; and even at the present time a pump is exhibited in which cannon balls are raised by this defective construction, the inventor imagining that an advantage may be

obtained by the defect. Some of the best pumps now constructed are those intended for nautical purposes; and the subjoined figure will serve to show the mode of combining power in these hydraulic machines.



The fire-engine is very similar to the double ship's pump, and has been in use, as it is now constructed, for more than a century; but a great improvement has lately been effected by Mr. Braithwaite. He employs a portable steam-engine to give motion to the pump-rod; and, as the steam is prepared during the passage of the fire-engine to its destination, we can hardly conceive a more effective or powerful hydraulic apparatus.

We may now briefly trace the history of *optical science*; and it will be seen that the discoveries connected with this branch of our subject are of a very interesting character. By the agency of optical instruments we are enabled to penetrate the most distant regions of space, and mark the forms and orbits of the planetary bodies; and at the same time, by a slight change in their construction, to bring before the eye of the curious investigator wonders in the animal and vegetable kingdoms which far surpass all that the wildest fictions of Arabian enchantment could devise. By the aid of the magnifying glass, even in its simplest form, we discover that almost every organized body teems with life and motion, and that, when one creature fades before the passage of time and seasonal change, another and frequently a more numerous species of sentient creatures is warmed into action and enjoyment by this apparently destructive process. In fact, we discover that the eye furnishes but the first link in the chain of creative goodness, and that every additional step that we take in the world of microscopic wonders furnishes a new proof of the all-pervading power of that Being whose

— Goodness guides the rushing wind,
And tips the bolt with flame;
Whose wisdom breathes in every breeze,
And warms with every beam.

The first systematic treatise on light is ascribed to Empedocles; and a work on optics, attributed to Euclid, who flourished about 400 years before the Christian era, shows the state of knowledge on the subject generally about that period. The latter work adverts to the effect of bringing into view, by refraction, an object at the bottom of a vessel, by pouring water upon it; but chiefly treats of reflected rays, explaining the effects of different kinds of mirrors, and demonstrating the equality of the angles of incidence and reflection. Ptolemy, in the second century, prepared a treatise on the science of optics generally, though it is

now lost. From this period but little occurs worthy of notice, till Alhazen, an Arabian author, in the eleventh century, gave an account of the magnifying power of lenses; and in 1270 Vitellio, a Pole, wrote a treatise on this science, containing all that was valuable in Alhazen, digested in a better manner, and with clearer explanations of various optical phenomena. He observes that light is always lost by refraction, which makes objects seen through lenses appear less luminous. He gave a table of the results of his experiments on the refractive powers of air, water, and glass, corresponding to the different angles of incidence. He ascribes the twinkling of the stars to the motion of the air in which the light is refracted; and illustrates this hypothesis by observing that they twinkle still more when the air is put in motion. He also asserts that refraction is necessary, as well as reflection, to form the rainbow; because the body which the rays fall upon is a transparent substance, at the surface of which one part of the light is always reflected and another refracted. He makes some ingenious attempts to explain refraction, or to ascertain the law of it; and considers the foci of glass spheres, and the apparent size of objects seen through them, though with but little accuracy.

John Baptista Porta of Naples was a very ingenious experimentalist, and is supposed, on good authority, to have been the inventor of the camera obscura. His experiments with that instrument induced him to believe that light must certainly be a substance, by the reception of which into the eye vision was accomplished. The importance of this suggestion will be evident when it is observed that previous to his time vision was supposed to be dependent upon what were termed visual rays proceeding from the eye. He justly considered the eye itself as a natural camera obscura, the pupil performing the office of the hole in the window-shutter: he remarked also that a defect of light is remedied by the dilatation of the pupil, which contracts involuntarily when exposed to a strong light, and expands when the light is too faint for distinct vision. Baptista Porta, by publishing an account of the magic lantern, tended very materially to diffuse a taste for scientific pursuits, as he was enabled with that ingenious instrument to amuse as well as to instruct his pupils.

The commencement of the seventeenth century is justly celebrated for the application of the telescope to astronomical purposes, and for this instrument we are most especially indebted to Galileo. Other accounts transfer the merit of the first discovery to Jansen, whose children, while amusing themselves with a series of spectacle-glasses in his shop, perceived that when they held two of these lenses between their fingers, at a certain distance from each other, the dial of the clock appeared greatly magnified, but in an inverted position. This incident suggested to their father the idea of adjusting two glasses on a board so as to move them at pleasure to any required distance. To the Jansens we are also indebted for the discovery of the microscope, an instrument depending upon exactly the same principles as the telescopic tube. In fact, it is not improbable that the double lens was first applied to the observation of near but minute objects, and afterwards on the same principles to objects which appeared minute on account of their distance. The discovery of the different refrangibility of the component rays of light suggested defects in the construction of telescopes which were before unthought of; and, in the creative hands of a Newton or a Dollond, led to some no less extraordinary improvements in them.*

* A very beautiful analogy between the microscope and this instrument has been drawn by Dr. Chalmers. He says, speaking of the two instruments, "The one led me to see a system in every star; the other leads me to see a world in every atom. The one taught me that this mighty globe, with the whole burden of its people and of its countries, is but a grain of sand on the high field of immensity; the other teaches me that every grain of sand may harbour within it the tribes and the families of a busy population. The one told me of the insignificance of the world I tread upon; the other redeems it from all its insignificance, for it tells me that in the leaves of every forest, and in the flowers of every garden, and in the waters of every rivulet, there are worlds

To proceed, however, in our historical view of the science of optics, it may be proper to state that it was Kepler who first clearly explained the effects of lenses in making the rays of a pencil of light converge or diverge. He showed that a plano-convex lens makes rays that were parallel to its axis to meet at the distance of the diameter of the sphere of convexity; but that, if both sides of the lens be equally convex, the rays will have their focus at the distance of the radius of the circle corresponding to that degree of convexity. But he did not investigate any rule for the foci of lenses unequally convex. He only says, in general, that they will fall somewhere in the medium between the foci belonging to the two different degrees of convexity. It is to Cavallieri that we owe this investigation. He laid down the following rule:—As the sum of both the diameters is to one of them, so is the other to the distance of the focus. All these rules concerning convex lenses are applicable to those that are concave; with this differcnce, that the focus is on the contrary side of the glass.

It is generally admitted that we are indebted to Kepler for the first development of the theory of the astronomical telescope. The *rationale* of this instrument is explained, and the advantages of it are clearly pointed out, by this philosopher, in his *Catoptrics;* but, what is very surprising, he never reduced his excellent theory into practice. Montucla conjectures that the reason why he did not make trial of his new instrument was his not being aware of the great increase of the field of view, so that, being engaged in other pursuits, he might not think it of much consequence to take any pains about the construction of an instrument which could do little more than answer the same purpose with those of which he was already possessed. He must also have foreseen that the length of this telescope must have been greater in proportion to its magnifying power, so that it might appear to him, upon the whole, not quite so good a construction as the former. It was not long, however, before Kepler's suggestion was acted on: Scheiner constructed an instrument on this principle, and published a description of it, in 1630. "If," says he, "you insert two similar lenses (that is, both convex) in a tube, and place your eye at a convenient distance, you will see all terrestrial objects inverted, indeed, but magnified and very distinct, with a considerable extent of view." He afterwards subjoins an account of a telescope of a different construction, with two convex eye-glasses, which again reverses the images, and makes them appear in their natural position. This disposition of the lenses had also been pointed out by Kepler, but had not been reduced to practice by him any more than the former. This construction, however, answered the end but very imperfectly; and father Rheita was the first who suggested the employment of three glasses, instead of two. This acquired the name of the *terrestrial telescope*, being chiefly used for viewing terrestrial objects. The invention of the telescope and microscope having incited mathematicians to a more careful study of dioptrics, and this having soon become a perfect science, by means of the discoveries of Snellius, many different constructions were offered to the public. Huyghens was particularly eminent for his systematic knowledge of the subject, and was the author of some of the chief improvements which were made on dioptrical instruments till the time of Dollond's great discovery. He was well acquainted with the theory of aberration arising from the

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teeming with life, and numberless as are the glories of the firmament. The one has suggested to me that beyond and above all that is visible to man there may be fields of creation which sweep immeasurably along and carry the impress of the Almighty's hand to the remotest scenes of the universe; the other suggests to me that within and beneath all that minuteness which the aided eye of man has been able to explore there may be a region of invisibles, and that, could we draw aside the mysterious curtain which shrouds it from our senses, we might there see a theatre of as many wonders as astronomy has unfolded—a universe within the compass of a point so small as to elude all the powers of the microscope, but where the wonder-working God finds room for the exercise of all his attributes, where he can raise another mechanism of worlds, and fill and animate them with all the evidences of his glory."

spherical figure of the glasses, and has pointed out several ingenious methods of diminishing them by proper constructions of the eye-pieces. He first showed the advantages of two eye-glasses on the astronomical telescope and double microscope, and gave rules for their construction, which both enlarges the field and shortens the instrument.

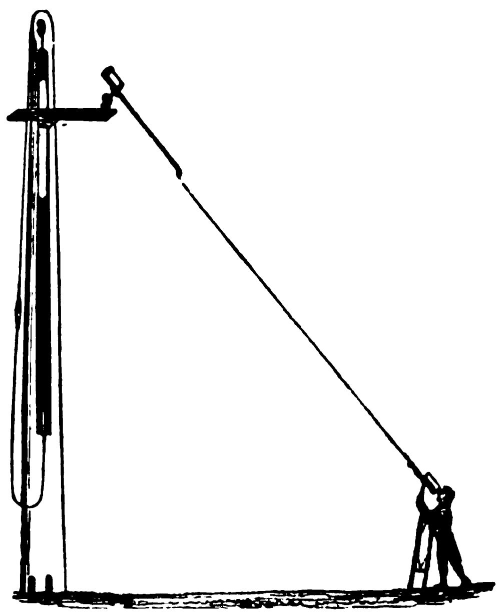
Des Cartes published a large work on optics in 1637, and from that period a considerable interval took place, during which optics, and indeed science in general, made but little progress, till the *Optica Promota* of James Gregory, in 1663, seemed to put them again in motion. The author of this work, a profound and inventive geometer, had applied diligently to the study of optics, and the improvement of optical instruments. The *Optica Promota* embraced several new enquiries concerning the illumination and distinctness of the images formed in the foci of lenses, and contained an account of the reflecting telescope, still known by the name of its author. The consideration which suggested this instrument was the imperfection of the images formed by spherical lenses, in consequence of which they are not in plane, but in curved surfaces. The desire of removing this imperfection led Gregory to substitute reflection for refraction in the construction of telescopes; and by this means, while he was seeking to remedy a small evil, he provided the means of avoiding a much greater one, with which he was yet unacquainted, viz. that which arises from the unequal refrangibility of light. The attention of Newton was about the same time drawn to the same subject, but with a perfect knowledge of the defect which he wanted to remove. Gregory thought it necessary that the specula should be of a parabolic figure; and the execution proved so difficult that the instrument, during his life, was never brought to any perfection. The specula were afterwards constructed of the ordinary spherical form; and the Gregorian telescope, till the time of Herschel, was more in use than the Newtonian.

Newton, in some of his earliest experimental investigations, applied himself to the improvement of the telescope; but, imagining that Gregory's speculum was neither very necessary nor likely to be executed, he began with prosecuting the views of Des Cartes, who aimed at making a more perfect image of an object by grinding lenses, not to the figure of a sphere, but to that of one of the conic sections. Whilst he was thus employed, three years after Gregory's publication, he had his attention particularly directed to the colours formed by a prism, and, having by means of that simple instrument discovered the different refrangibility of the rays of light, he then perceived that the errors of telescopes arising from that cause alone were some hundred times greater than such as were occasioned by the spherical figure of the lenses. This circumstance forced, as it were, Newton to fall into Gregory's track, and to turn his thoughts to reflectors. "The different refrangibility of the rays of light," says he, in a letter to Mr. Oldenburg, secretary of the Royal Society, "made me take reflectors into consideration, and finding them regular, so that the angle of reflection of all sorts of rays was equal to the angle of incidence, I understood that by their mediation optical instruments might be brought to any degree of perfection imaginable, provided a reflecting substance could be found which would polish as finely as glass, and reflect as much light as glass transmits, and the art of communicating to it a parabolic figure be also obtained. Amidst these thoughts I was forced from Cambridge by the intervening plague, and it was more than two years before I proceeded further."

Optics, as well as all the other branches of natural philosophy, have great obligations to Huyghens. The former was among the first scientific objects which occupied his mind; and his *Treatise on Optics*, though a posthumous work, is most of it the composition of his early youth. It is written with great perspicuity and precision, and is said to have been a favourite book with Newton himself. Though beginning from the first elements, it contains a full development of the matters of greatest difficulty in the construction of telescopes, particularly in what concerns the indistinctness arising from the imperfect foci into which rays are

united by spherical lenses; and rules are deduced for constructing telescopes which, though of different sizes, shall have the same degree of distinctness, illumination, &c. Huyghens was, besides, a practical optician: he polished lenses and constructed telescopes with his own hands, and some of his object-glasses were of the enormous focal distance of 130 feet.

It is generally supposed that the great reflecting telescopes employed in modern times have a greater focal length than any which had preceded them. This, however, is not the fact, as refracting telescopes of much greater length had really been attempted to be employed by M. Auzot in France in the seventeenth century. The enormous instruments made by Huyghens and others at the same period were employed without a tube. Huyghens placed his object-glass in a tube at the top of a long pole; the axis of this tube he could command with a silk string, so as to bring it into a line with the axis of another short tube which he held in his hand, and which contained the eye-glass. In the subjoined engraving we have attempted to delineate one of these extraordinary instruments, which for cheapness far surpasses any thing of the kind now used. It will, however, be sufficiently obvious that the important discoveries made with the Herschellian telescope could never have been effected by this instrument.



Prior to the invention of the achromatic glass it was generally supposed that the objects viewed through the telescope must in every form of the instrument be coloured, though some vague hopes, grounded chiefly on the consideration of final causes, were still at times entertained of removing that defect. As the eye consists of two distinct humours, with a horny lens or cornea interposed, it was naturally imagined that such a perfect structure should be imitated in the composition of glasses. This inviting idea is concisely mentioned by David Gregory, the nephew of James, in his little tract on dioptrics. It has also been stated that a country gentleman, Mr. Hall of Chesterhall, in Worcestershire, discovered, about the year 1729, the proper composition of lenses by the united segments of crown and flint-glass, and caused a London artist in 1733 to make a telescope under his directions, which was found on trial to answer extremely well. But, whatever might be the fact, no notice was taken of it at the time, nor indeed till very long after, when circumstances had occurred to call public attention to the subject.

The Newtonian principle was first publicly examined, and a discussion excited which eventually led to a most valuable discovery in optics by a foreign mathematician of great celebrity and transcendant talents. Leonard Euler was a very distinguished mathematician, and especially directed his attention to the subject of optics. Endowed with a penetrating genius and profound capacity, he was capable of pursuing his abstruse investigations with unremitting ardour and unwearied perseverance. To him the modern analysis stands chiefly indebted for its prodigious extension, and he continued to enrich it in all its departments with innumerable improvements and fine discoveries during the whole course of a most active, laborious, and protracted life. Unfortunately the philosophical character of Euler did not correspond to his superlative eminence as a geometer. Bred in the school of Leibnitz, he had

imbibed the specious but delusive metaphysics of the *sufficient reason*, and of the necessary and absolute constitution of the laws of nature. He was hence disposed in all cases to prefer the mode of investigating *à priori*, and never appeared to hold in due estimation the humbler yet only safe road to the knowledge of physical science, by the method of experiment and induction. In the *Berlin Memoirs* for 1747 he inserted a short paper, in which he deducted from optical principles by a clear analytical process, conducted with his usual skill, the composition of a lens formed after certain proportions with glass and water, which should remove entirely all extraneous colours, whether caused by the unequal refraction of the several rays or by spherical aberration; and, in concluding, he remarked, with high satisfaction, the general conformity of his results with the wonderful structure of the eye.

But this paper met with opposition in a quarter where it could have been least expected. John Dollond, who had afterwards the honour of completing one of the finest and most valuable discoveries in the science of optics, was born in 1706, in Spitalfields, of French parents, whom the edict of Nantes had compelled to take refuge in England from the cruel persecution of an ignorant and bigoted tyrant. Following his father's occupation, that of a weaver, he married at an early age; and being fond of reading he dedicated his leisure moments to the acquisition of knowledge. By dint of solitary application, he made some progress in the learned languages; but he mainly devoted his attention to the study of geometry and algebra, and the more attractive parts of mixed or practical mathematics. He gave instructions in these branches to his son Peter, who, though bred to the hereditary profession, soon quitted that employment, and commenced the business of optician, in which he was afterwards joined by his father. About this time the volume of the *Berlin Memoirs*, containing Euler's papers, fell into the hands of the elder Dollond, who examined it with care, and repeated the calculations. The result of his examination was communicated by Mr. Short to the Royal Society in 1752, and published in their *Transactions* for that year. Dollond, as might well be expected, could detect no mistake in the investigation itself, but strenuously contested the principle on which it was built, as differing from the one laid down by Newton, which he held to be irrefragable. "It is, therefore," says he, rather uncourteously, and certainly with little of the prophetic spirit, "it is therefore somewhat strange that any body now-a-days should attempt to do that which so long ago has been demonstrated impossible." The great Euler replied with becoming temper, but persisted in maintaining that his optical principle was a true and necessary law of nature, though he frankly confessed that he had not been able to reduce it yet to practice. Unsatisfied by the arguments of Euler, the humble and unassisted optician applied himself closely to experimental investigation, and, having proved the power of an achromatic arrangement of prisms, next tried so to adapt the opposite refractions as to destroy all extraneous colour. This effect he found to take place when the angle of the wedge had been further increased till the refracting power of the water was to that of the glass in the ratio of five to four. His conclusive experiments were made in 1757, and he lost no time in applying their results to the improvement of the object-glasses of telescopes. Following the proportion just ascertained, he conjoined a very deep convex lens of water with a concave one of glass. In this way he succeeded in removing the colours occasioned by the unequal refraction of light; but the images formed in the foci of the telescopes so constructed still wanted the distinctness which might have been expected. The defect now proceeded, it was evident, from spherical aberration; for, the excess of refraction in the compound lens being very small, the surfaces were necessarily formed to a very deep curvature. But this partial success only stimulated the ingenious artist to make further trials. Having proved that the separation of the extreme rays, or what has been since termed the *dispersive power*, is not proportioned to the mean refraction in the case of glass and water, he might fairly presume that like discrepancies must exist among other diaphanous substances,

and even among the different kinds of glass itself. Having made this discovery, which at once furnished him with the materials for his achromatic arrangement, Mr. Dollond was encouraged to proceed, with the confident hope of ultimately achieving his purpose. His new researches, however, were postponed for some time by the pressure of business. But, on resuming the enquiry, he found the English crown-glass and the foreign yellow or straw-coloured, commonly called the Venice-glass, to disperse the extreme rays almost alike, while the crystal, or white flint-glass, gave a much greater measure of dispersion. A wedge of crown and another of flint-glass were afterwards ground till they refracted equally, which took place when their angles were respectively 29° and 25°, or the indices of refraction were nearly as 22 to 19; but, on being joined in an inverted position, they produced, without changing the general direction of the pencil, a very different divergence of the compound rays of light. He now reversed the experiment, and formed wedges of crown and flint-glass to such angles as might destroy all irregularity of colour by their opposite dispersions.

In 1758 the labours of Mr. Dollond were rewarded with complete success. "Notwithstanding," says he, in concluding his paper, "so many difficulties as I have enumerated, I have, after numerous trials, and a resolute perseverance, brought the matter at last to such an issue that I can construct refracting telescopes with such apertures and magnifying powers, under limited lengths, as, in the opinion of the best and undeniable judges, who have experienced them, far exceed any thing that has been produced, as representing objects with great distinctness, and in their true colours." The Royal Society voted to Mr. Dollond, for his valuable discovery, the honour of the Copley medal. To this new construction of the telescope, Dr. Bevis gave the name of *achromatic*, which was soon universally adopted, and is still retained. The inventor took out a patent, but did not live to reap the fruits of his ingenious labours. He died in the year 1761, leaving the prosecution of the business to his son and associate, Peter Dollond, who realized a very large fortune by the exclusive manufacture, for many years, of achromatic glasses, less secured to him by the invidious and disputed provisions of legal monopoly than by superior skill, experience, and sedulous attention. In 1765, the younger Dollond made another and final improvement, to which his father had before advanced some steps. To correct more effectually the spherical aberration, he formed the object-glass of three instead of two lenses, by dividing the convex piece; or he enclosed a concave lens of flint-glass between two convex lenses of crown-glass.

Mr. Tulley has succeeded in applying the achromatic principle of Dollond to the smallest sized glasses, and the improvements effected by Guinaud and Faraday, in the manufacture of glass, have given to this portion of the telescope a degree of excellence which could hardly have been contemplated by the opticians to whose labours we have had occasion to allude. Aided by instruments of this description, astronomers have been able to observe not only stars, planets, and satellites, invisible to the naked eye, but to measure the height of mountains in our own satellite, and discover volcanoes, or burning mountains, on its surface.

We are mainly indebted to the late Sir William Herschel for the improvements that have been made in the reflecting telescope. In 1781, Sir William Herschel began a thirty-feet aërial reflector; but his mirror, thirty-six inches in diameter, having at one time cracked in the cooling, and at another period run into the fire, from a failure in the furnace, his object was partially abandoned. But, the plan for forming a telescope of extraordinary size having been submitted by Sir Joseph Banks to the king, his majesty offered to defray the expense of it, and, under his patronage, this distinguished optician began, about the end of the year 1785, to construct a telescope of forty feet in focal length. This splendid instrument, which magnified 6450 times, was completed on the 27th of August, 1789; and on the day following Herschel discovered a new satellite belonging to the planet Saturn.

In the article MICROSCOPE we have fully traced the various improvements that have been effected in that instrument from the time of Leuenhoek to the present period; and we may content ourselves with remarking that the microscope, as it is now constructed, amazingly extends the boundaries of the organs of vision, enables us to examine the structure of plants and animals, presents to the eye myriads of beings of whose existence we had before formed no idea, and furnishes the philosopher with an exhaustless field of investigation. "It leads," to use the words of an ingenious writer, "to the discovery of a thousand wonders in the works of his hand who created ourselves, as well as the objects of our admiration; it improves the faculties, exalts the comprehension, and multiplies the inlets to happiness; it is a new source of praise to him to whom all we pay is nothing of what we owe; and, while it pleases the imagination with the unbounded treasures it offers to the view, it tends to make the whole life one continued act of admiration." The oxy-hydrogen microscope is peculiarly fitted to explain, on a large scale, the wonders of the animal and vegetable kingdoms: and its simplicity is such that any person who has a sufficient practical acquaintance with chemistry to produce the steady white light which results from the combustion of the oxy-hydrogen gases on lime may employ the apparatus.

The micrometer is an important part both of the telescopic and microscopic apparatus, and as such must not be passed unnoticed. By the aid of a micrometer we may either measure the size of a planetary body or the smallest object of microscopic investigation. But little use was made of the micrometer for telescopic purposes till the time of Mr. Ramsden, who invented two instruments of this description. Sir William Herschel, also, invented a lamp micrometer, which he employed with one of his powerful telescopes. Cavallo's micrometer is simple and valuable. It consists of a small semi-transparent scale, or slip of mother-of-pearl, about the twentieth part of an inch broad, and of the thickness of common writing-paper. It is divided into a number of equal parts, by means of parallel lines, every fifth and tenth division of which is a little longer than the rest. This micrometer, or divided scale, is situated within the tube, at the focus of the eye-lens of the telescope, where the image of the object is formed, and with its divided edge passing through the centre of the field of view, though this is not absolutely necessary. It is immaterial whether the telescope be a refractor or a reflector, provided the eye-lens be convex, and not concave, as in the Galilean telescope.

The mother-of-pearl micrometer may be applied to a microscope, and it will thus serve to measure the lineal dimensions of an object. In some of the best forms of the micrometer, the eye-tube through which the object is viewed is divided by threads or filaments, and scientific men have often had occasion to regret the difficulty of procuring fibres sufficiently elastic for micrometers. The difficulty of obtaining silver wire of a diameter small enough induced Mr. Troughton to use the spider's web, which he found so fine, opaque, and elastic, as to answer all the purposes of practical astronomy. But, as it is only the stretcher, or long line which supports the web, that possesses these valuable properties, the difficulty of procuring it has compelled many opticians and practical astronomers to employ the raw fibres of unwrought silk, or, what is still worse, the coarse silver wire manufactured in this country. For these Sir David Brewster has succeeded in obtaining a substitute in a delicate fibre, which enables the observer to remove the errors of inflection, while it possesses the requisite property of opacity and elasticity. This fibre is made of glass, which is so exceedingly elastic that it may be drawn to any degree of fineness, and which can always be procured and prepared with facility. This vitreous fibre, when drawn from a hollow tube, will always be of a tubular structure, and its interior diameter may always be regulated by that of the original tube. When such a fibre is formed, and stretched across the diaphragm of the eye-piece of a telescope, it will appear perfectly opaque, with a delicate line of light

extending along its axis. As this central transparency arises from the transmission of the incident light through the axis of the hollow tube, and this tube can be made of any calibre. the diameter of the luminous streak can either be increased or diminished. In a micrometer fitted up in this way by Sir David Brewster, the glass fibres are about 1-1200th part of an inch in diameter; and the fringe of light is distinctly visible, though it does not exceed 1-3000th part of an inch. The inventive genius of Dr. Wollaston has, however, far outstripped those who preceded him in the production of a micrometer fibre. The contrivance by which it is effected is so ingenious, and promises to be productive of such beneficial results, that it may be advisable to annex the account of the process employed by this philosopher.—"The extremity of a platinum wire, having been fused into a globule nearly one-fourth of an inch in diameter, was next hammered out into a square rod, and then drawn again into a wire 1-253rd of an inch in diameter. One inch of this wire, duly coated with silver, was drawn till its length was extended to 182 inches. The silver was then destroyed by the action of a corrosive acid, leaving the exquisitely minute core of platinum for the micrometer fibre."

The nature of light must now more particularly engage our attention. There are two theories, or rather hypotheses, that have been adopted to explain the action of light with reference to its transmission: the one supposes the ray to consist of small particles, and as such material; while the other presumes the existence of a fluid, pervading all space, which, by its vibratory motion, enables us to see luminous bodies. According to the latter hypothesis light may be considered as analogous to sound, which is known to depend entirely upon the pulsations of the air and other sonorous bodies transmitting a vibratory motion to the organs of hearing. A very striking circumstance respecting the propagation of light is the uniformity of its velocity in the same medium. According to the projectile hypothesis, the force employed in the free emission of light must be enormously greater than the force of gravity at the earth's surface, and it must either act with equal intensity on all the particles of light, or must impel some of them through a greater space than others if its action be less powerful, since the velocity is the same in all cases; for example, if the projectile force is weaker with respect to red light than with respect to violet light, it must continue its action on the red rays to a greater distance than on the violet rays. There is no instance in nature besides of a simple projectile moving with a velocity uniform in all cases whatever may be its cause; and it is extremely difficult to imagine that so immense a force of repulsion can reside in all substances capable of becoming luminous, so that the light of decaying wood, or of two pebbles rubbed together, may be projected precisely with the same velocity as the light emitted during the combustion of iron in oxygen gas, or by the reservoir of liquid fire on the surface of the sun. Another cause would also naturally interfere with the uniformity of the velocity of light if it consisted merely in the motion of the projected corpuscles of matter. M. Laplace has calculated that, if any of the stars were 250 times as great in diameter as the sun, their attraction would be so strong as to destroy the whole momentum of the corpuscles of light proceeding from it, and to render the star invisible at a great distance; and, although there is at present no reason to imagine that any of the stars are actually of this magnitude, yet some of them are probably many times greater than our sun, and therefore large enough to produce such a retardation in the motion of its light as would materially alter its effects.

If, however, we adopt the opinion that the particles of light are material, and that they are continually passing from the various luminous bodies that surround us, it may be enquired why do they not interfere with each other in such a manner as to confound all perception of objects, if not quite destroy the sense of seeing? Their velocity, however, enables us to answer these questions, by convincing us that they may be separated at least 1000 miles, and

yet be perfectly efficient for the purposes of vision. It is an undoubted fact that the effect of light upon the eye is not instantaneous, but that the impression remains after the light has been withdrawn. Of this any one may satisfy himself by shutting his eye after having looked for some time on a candle, a star, or any other luminous object, when a faint momentary picture of the object will remain. The same thing may be proved by whirling round a stick, the extremity of which is on fire, if the motion be quick enough the perception of a complete circle of flame will be impressed upon the eye. The actual duration, for a certain time, of the impression of light being thus proved, let it be supposed to continue distinct only for the 150th part of a second; then, if one lucid point of the sun's surface emit 150 particles of light in a second, these will be amply sufficient to afford light to the eye without any intermission, and yet the particles emitted will be more than 1000 miles apart. It has been ascertained by the astronomical observations of Roemur and Bradley that each ray of light emitted by the sun arrives at the earth in eight minutes and one-eighth when the earth is at the mean distance of about 95,000,000 miles. Roemur deduced this velocity from observations on the eclipses of the satellites of Jupiter; and Bradley confirmed it by his discovery of the cause of the apparent aberration of the fixed stars. But we have other proofs not less decisive than this of the extreme minuteness of the particles of light, when we observe with what facility they penetrate the hardest bodies, as glass, crystal, precious stones, and even the diamond itself, through all which they find an easy passage, or those bodies could not be transparent. When a candle is lighted, if there is no obstacle to obstruct its rays, it will fill a space of two miles round with luminous particles in an instant of time, and before the least sensible part is lost by the luminous body. Nay, how small must the particles of light be, when they pass without removing the minutest particles of microscopic dust that lie in their way, and even these minute particles are rendered visible by reflecting back the particles of light that strike against them. Some bodies intercept light, or are opaque; others allow its transmission, and as such are transparent; and there are gradations from perfect opacity to perfect transparency. It is probable that opacity results from the attraction of the substance for light, and not from its density; for it can scarcely be supposed that the particles of bodies should not be far enough distant to allow of the passage of light. Newton supposes the particles of transparent bodies to be of uniform density and arrangement, and, attracting the rays of light equally in every direction, they suffer it to pass through them without obstruction; whereas, in opaque bodies, the particles are either of unequal density or irregularly arranged, and the light, being unequally attracted, cannot therefore penetrate the body.

Experience has long since established the fact that vegetables become destitute of smell and colour, and lose much of their combustibility, by growing in the dark. In Dr. Black's *Lectures* we find an illustration of this circumstance given by the celebrated Dr. Robinson, of Edinburgh. In the drain of a coal-work, under ground, he accidentally laid his hand upon a very luxuriant plant, with large indented foliage, and perfectly white. He had not seen any thing like it, nor could any one inform him what it was. He had the plant brought into the open air in the light. In a little time the leaves withered, and soon after new leaves began to spring up, of a green colour and of a different shape from that of the old ones. On rubbing one of the leaves between his fingers, he found that it had the smell of common tansy, and ultimately it proved to be that plant, which had been so changed by growing in the dark. Indeed, it was recollected that some rubbish had been taken down into the drain from a neighbouring garden, some time before it was found so altered. This effect of light is not less conspicuous in the growth of celery. By covering it with earth, the light is shut out, which would very soon turn it green, and render its flavour so strong as to make it unfit to be eaten, at the same time that it would render it more fibrous.

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We have seen that light is refracted in passing from one medium to another, and that this property is employed in the formation of lenses for optical instruments. Familiar examples of the effects of natural refraction may be adduced by the bending of the image of a rod placed obliquely in water, or the exquisitely painted spectrum depicted in the heavens by the drops of falling rain. These paradoxical effects were observed at an early period; but the most singular of all the phenomena of refraction is, perhaps, the property of some natural substances, which have a double effect on the light transmitted through them, as of two mediums of different densities, freely pervading each other, the one only acting on some of the rays of light, the other on the remaining portion. These substances are usually crystallized stones, and their refractions have sometimes no further peculiarity; but the rhomboidal crystals of calcareous spar, commonly called *Iceland crystal*, possess the remarkable property of separating such pencils of light as fall perpendicularly on them into two parts, one of them only being in the usual manner, the other being deflected towards the greater angle of the crystal. It appears from the experiments of Huyghens, confirmed and extended by Dr. Wollaston and Sir David Brewster, that the medium which causes the unusual refraction has a different refractive power, according to the direction in which the light passes through it; and if an oblate or flattened spheroid be described within a circle, its axis being in the middle of one of the obtuse solid angles, and its principal diameters in the proportion of nine to ten, the refractive power, with respect to light passing in any direction, will always be inversely as the diameter of the spheroid which is parallel to it, and where it is greatest will be equal to that of the medium which produces the usual refraction. A ray of light falling perpendicularly on any surface of the spar, its point of incidence being considered as the centre of the spheroid, will meet the surface of the spheroid at the point where it is parallel to that of the spar; and a ray incident on the same surface in any other direction will preserve a relation to the perpendicular ray which is nearly the same as in ordinary refraction.

There is a considerable analogy subsisting between some of the phenomena of light, electricity, and magnetism. *Electricity* appears to pervade the whole of created nature, and yet our acquaintance with some of its most simple phenomena can scarcely be traced further than the middle of the last century. We have already had occasion to advert to the experimental labours of Grey, a pensioner of the charter-house. He was followed in the march of discovery by Dufay, who, in 1733, described the existence of two opposite species or kinds of electricity. These he called the *vitreous* and the *resinous*, the former being excited by rubbing glass, and the latter by the friction of amber, resin, &c. He also gave a clear view of the phenomena of electrical attraction and repulsion, by demonstrating that bodies similarly electrified mutually repel, while those dissimilarly electrified attract each other. We have exhibited, at page vi., the simple electrical apparatus employed by these early experimentalists; and Francis Hawksbee appears to have been the first to employ a globe of glass to collect the electric fluid. One or more gun-barrels, suspended horizontally by silk cords, were furnished with small bundles of linen threads, and the curious found amusement in drawing sparks, and firing inflammable substances. After this electricity became a favourite remedy with the empirics; and in 1745 a very important discovery was made at Leyden, where Messrs. Cuneus and Lallemand, in attempting to electrify some water contained in a glass vessel, received a severe shock. By this singular discovery, a power was obtained incomparably greater than that of the mere spark.*

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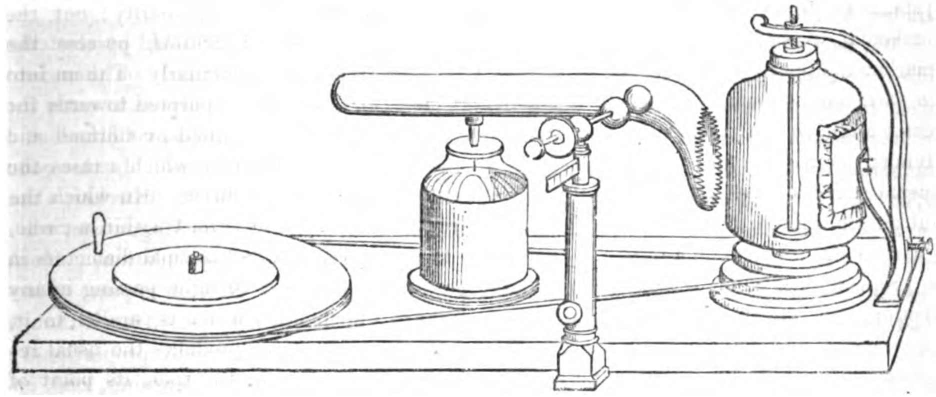
* The shock or convulsive agitation accompanying the discharge of a loaded jar through the nervous system at first inspired terror, and still continues to excite surprise and astonishment. The swiftness of electrical communication thus displayed seemed to exceed the rapidity of thought itself. Nollet, a popular lecturer on experimental philosophy at Paris, sent the shock, with instantaneous effect, through a whole

The analogy which subsists between electricity produced by artificial means and that which results from the passage of an electrical cloud appears to have been first satisfactorily pointed out by Dr. Benjamin Franklin. His experiments also led to the formation of an hypothesis intended to illustrate the existence of electricity in a positive and negative state, so that, when the Leyden jar has its electrical equilibrium destroyed by communication with the electrical machine, the one side of the jar is plus and the other minus. The apparatus employed for exhibiting these and other experiments now assumed a new and improved character. The stick of glass was replaced by a glass globe, or cylinder, whirled round by a large wheel and cord, such as is shown in the subjoined wood-cut.



Dr. Franklin, continuing his experimental researches, was enabled, by the agency of a kite raised to a considerable height, to bring down the electric fluid naturally from the atmosphere. The success of this trial encouraged him to entertain the bold project of turning aside the stroke of the thunderbolt, and of guarding our edifices from the flash of the forked lightning, by the erection of lofty conductors.

The power of benumbing the touch, which belongs to a certain fish of the ray kind, thence called the torpedo, and very frequent in the Mediterranean, had been remarked from the earliest times. This singular property was now suspected to be owing to electrical influence; and the zeal of Walsh, in 1733, converted the conjecture into demonstration, showing, by satisfactory experiments, that the animal could send its shock only through conducting substances. But the power of stunning its prey is possessed in a much higher degree by the *silurus electricus*, which was originally brought from Surinam, and abounds in the pools and sluggish streams in the hot region of Venezuela. From a healthy specimen exhibited in London vivid sparks were drawn in a darkened room.

The discoveries of Galvani and Volta formed a new era in the progress of this science. Galvani, professor of anatomy at Bologna, remarked, in the course of his demonstrations, that the limbs of a dissected frog were strongly convulsed at every spark which one of his pupils happened to draw from the prime conductor of an electrical machine standing in the immediate vicinity. Being thus led to consider the subject, he made several curious experiments, and published a *Dissertation on Animal Electricity*, which engaged very general attention. The femoral muscles of a frog, bared of their integuments, but left connected with the trunk of nerves, were found to serve as a most delicate sort of electrometer. With

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regiment of guards; and Watson, an ingenious physician in London, could discover no interval of time in its transmission through a circuit of about six miles. Helvig, however, seems to have measured its velocity by the aid of a camera lucida, and Mr. Wheatstone has lately contrived an instrument which registers the precise time that it occupies to pass over a given distance.

this aid it was easy to trace the faintest vestiges of electrical influence, and to contrast the properties of various conductors. The very weakest chemical solutions, the mere contact of different metals, nay, the apposition of animal fibres, were all found in their several degrees to develope electricity. But the simplest mode of exciting it now known is by the mutual application of small disks of copper and zinc. Volta, in 1800, invented the *pile*, which still bears his name, the most energetic instrument of all electro-chemical analysis, and commencing deservedly a new epoch in physical science. By Cruikshanks it was rendered far more commodious, in being converted into the Galvanic trough, which again enlarged into batteries, sometimes of enormous extent or dimensions, has conducted Davy, Berzelius, Faraday, &c., to the most splendid and wonderful discoveries.

We have seen that there are peculiar attractions and repulsions exhibited by electrified bodies; now nearly similar phenomena occur with those that are magnetized. The ancients appear to have known but little of *magnetism*. It is not our present purpose to enter into the long-disputed question as to whether the compass was really invented by Columbus, or whether, as some suppose, the honour of its discovery belongs to the Chinese. In this country, at least, but little was known of the matter till the time of Dr. Gilbert. Kircher, a man of extraordinary talent and erudition, produced at Cologne a full treatise on Magnetism, which contained little however of sound doctrine, but abundance of fanciful speculation. Hooke remarked the injurious effect of heat on the power of the magnet. Newton appears to have sometimes amused himself with magnetic experiments, but he did not bestow much thought on the subject: he was disposed to consider the force exerted as reciprocally proportional to the cube of the distance. The celebrated Halley, who by his ingenuity, learning, zeal, and enterprise, contributed so largely to the promotion of physical science, now turned his attention to the subject of terrestrial magnetism. In 1683, and more distinctly in 1692, he endeavoured to explain the declination of the needle and its variations, by supposing the earth to be a hollow sphere, containing a magnet of analogous polarity, which revolved slowly within it. From this bold hypothesis, of two fixed, combined with two movable poles, he sought to calculate the changes of internal constitution that are continually going forward. Coulomb was enabled by the aid of his balance of Torsion to discover the true law of magnetic attraction and repulsion. The earlier experimentalists had sought to ascertain those forces by the loads required to effect a separation, or to counterbalance their action. Graham proposed the more precise method of computing the magnetic forces from the number of vibrations performed in a given time by the needle; but his suggestion was overlooked, to be afterwards invented again, and generally adopted. The properties of the magnet appear mysterious, though reducible to a few primary facts. But to discover the great pervading principle still baffles the ingenuity and penetration of the most ardent research.

We have briefly adverted to the magnetic theory of Dr. Halley. Alpinus adopted a different and more fanciful hypothesis for explaining the phenomena of magnetism and electricity; he also furnished an improved method suggested by his theory for imparting magnetism to steel bars, by what he called the "double-touch." But, with regard to the mechanical processes for communicating magnetism, they have all been considerably improved by captain Scoresby. Forster made some very important magnetical observations during one of the late polar voyages. But the greatest modern discovery in magnetism is due to Professor Barlow of Woolwich, who has pointed out the mischievous effects produced by the magnetic influence of the metal in a vessel; and suggested a beautiful contrivance for remedying its very injurious influence on the compass.

The science of *electro-magnetism* mainly dates its origin from the time of Oersted, whose first experiments were made early in the present century. Prior to that period, however, we find Franklin, and Van Marum, pointing out the power which a common electrical machine

possessed of imparting magnetism to ferruginous bodies. So powerful was the magnetism produced by the discharge of a small electrical battery, through a wire one-twentieth of an inch in diameter, that it rendered bars of steel two inches long highly magnetic. In Oersted's early experiments, he proposed to ascertain "whether electricity the most latent had any action on the magnet." He soon ascertained that an electrical current passing from the positive to the negative pole of a Voltaic battery would cause a magnetic needle, placed near it, to deviate from its natural position. He was thus led to believe that the electric action was not enclosed within the conducting wire, but that it must possess an extensive sphere of action around it. He was also led to conclude that the above influence acted by revolution; for without such a supposition it was impossible to conceive how the wire, when its position was changed with reference to the needle, should act in opposite directions. Oersted's experiments were no sooner published than they were repeated and varied by philosophers in every part of Europe; and a multitude of new facts were soon brought to light, through the labours of Davy, Faraday, Ampère, Biot, and Arago.*

The study of the heavenly bodies, and as such the dawn of *astronomical science*, must evidently be as old as the creation; though, in all probability, the astronomer of that period confined his observations to the more obvious motions of the sun and moon, the rising and setting of the principal stars, and the apparent motions of the planets. The progress of the sun being thus followed, the regular transitions from day to night would at once be understood. The level and extensive plains of Chaldea peculiarly fitted that favoured portion of the globe to the study of astronomy; and the clear nights which the inhabitants were wont to pass in the open air, united to a pure and serene sky and an unbroken horizon, all conspired to engage that people to contemplate the motions of the stars, and to lead them to conjecture on the laws by which they were governed. From Chaldea, astronomy passed into Egypt, and was soon afterwards carried into Phœnicia, where the people began to apply the observations which had been made to the uses of navigation, and thus rendered themselves both the masters of the sea and of commerce. Their guide, in steering their ships, when far from land, was one of the stars in the constellation called the Little Bear, which, unlike other stars, appeared always to retain the same situation. Other nations, less skilful in astronomy, observed only the Great Bear in their voyages,—a guide too imperfect to enable them to lose sight of land with safety. But the most ancient observations of which we are in possession, that are sufficiently accurate to be employed in astronomical calculations, were made at Babylon, about seven centuries prior to the Christian era: they relate to three eclipses of the moon; and Ptolemy, who has transmitted them to us, employed them for determining the period of the moon's mean motion, and therefore had probably none more ancient on which he could depend. To Anaximander, one of the disciples of Thales, is ascribed the invention of the terrestrial globe, and of a gnomon which he erected at Sparta, by means of which he observed the equinoxes and solstices, and

* A very remarkable fact, for which we are indebted to the latter philosopher, may here be briefly noticed. He found that a needle, suspended over a revolving plate of copper, was drawn aside from the meridian in the direction of the motion, and that, when this became very rapid, it would even follow the tide of circumvolution. It was at first supposed that this very extraordinary effect was produced by the action of a current of atmospheric air; but, when the plate was enclosed in a glass box, the needle still continued to revolve. It may be proper to add that a variety of other bodies were afterwards substituted for the copper plate, with a similar result.

The connection which subsists between the electrical and magnetic influences influenced by heat was, we believe, first pointed out by Dr. Seebeck, of Vienna, in 1823. He found that, by combining metals of different kinds, deflections of the magnetic needle might be produced by a change of temperature alone, without the assistance of any Voltaic arrangement. A very valuable list of thermo-electrics has been furnished by professor Cumming, and M. Ampère ascribes the diurnal variation of the needle to the corresponding motion of the globe, which produces a continued variation in its temperature.

determined the obliquity of the ecliptic, more exactly than had ever been done before. The Greeks, assisted by the instructions they had received from Thales and Anaximander, ventured to make considerable voyages, and planted several colonies in remote countries; yet the latter philosopher and his children were proscribed by the Athenians; and their lives would have been sacrificed but for Pericles, through whose influence the sentence was commuted for banishment. The charge against him was the discovery of truth; for it was thought impious to suppose "that the works of the gods could be subject to immutable laws."

Pythagoras, another disciple of Thales, taught many important astronomical truths. To him is attributed the discovery of the true system of the world, which, after the lapse of many centuries, was revived by Copernicus, and which is now settled on the basis of so many truths that it can never be overthrown. It was thought, even in his school, that the planets were inhabited like the earth; and that the stars, which are disseminated through infinite space, are suns, and the centres of other planetary systems. He is also said to have considered the comets as permanent bodies, moving round the sun; and not as perishing meteors formed in the atmosphere, as they were thought to be in after times. The Arabian school of astronomy commenced with Almamoun, the son of the caliph Haroun al Raschid. This celebrated warrior and philosopher, having conquered the emperor Michael III., made it a condition of peace that a copy of the works of each of the best Greek authors should be delivered to him, and among them were the works of Ptolemy, of which he procured an Arabic translation. This occurred in the ninth century; and, about 400 years later, the work of Ptolemy was translated into the Latin language. The fifteenth century was rendered memorable by the revival of the Pythagorean system. This was effected by Nicholas Copernicus, a native of Thorn in Prussia. The Ptolemaic system, which supposes the earth to be fixed in the centre of the universe, and the sun and moon, with Mercury, Venus, and the other planets, revolving round it in concentric circles, he perceived to be inconsistent with the celestial phenomena, and encumbered with many absurdities, which did not affect the hypothesis which considered the sun to be in the centre, and the earth a planet revolving about it annually, with the rest, and daily turning upon its own axis.

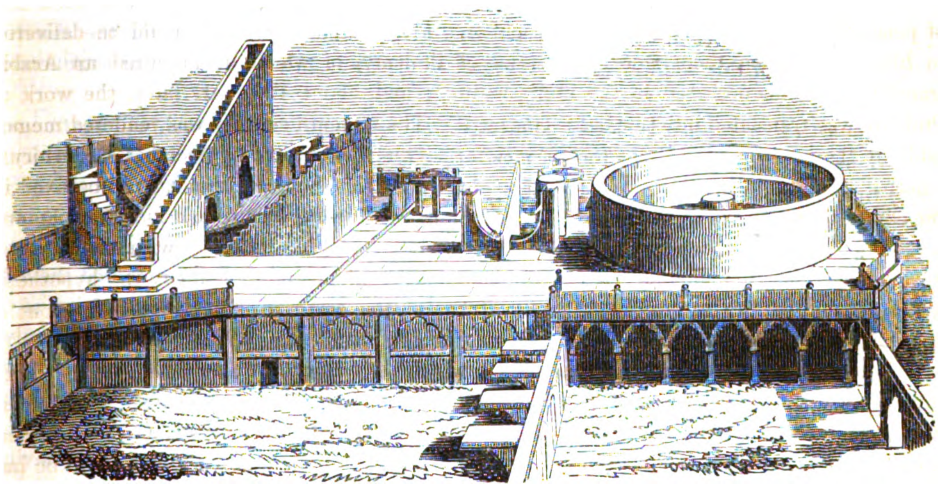
The only opposition of any consequence which the theory of Copernicus ever met with from science and argument proceeded from Tycho Brahe, a celebrated Danish astronomer, who attempted to set up against it a theory of his own. His system is not very different from the Ptolemaic, but is generally called by his name. He supposed the earth to be immovable in the centre of the universe, and the sun to revolve about it every twenty-four hours; the planets, he thought, went round the sun in their periodical times, Mercury being nearest to that luminary, then Venus, Mars, Jupiter, and Saturn; and of course to revolve also about the earth. But some of Brahe's disciples supposed the earth to have a diurnal motion round its axis, and the sun, with all the planets, to move round the earth in one year.

Kepler was one of the pupils of Tycho Brahe, and a man of a truly original genius. Hipparchus, Ptolemy, Tycho Brahe, and even Copernicus himself, were indebted for a great part of their knowledge to the Egyptians, Chaldeans, and Indians. Pursuing paths already pointed out, they did little more than separate fancy from fact, with more or less success; but Kepler, by his own talent and industry, made discoveries of which no traces are to be found in the annals of antiquity. Galileo was contemporary with Kepler; and whilst the latter was tracing the orbits of the planets, and settling the laws of their motions, he was investigating the doctrine of motion in general, which had been neglected for 2000 years; and, from the result of their united labours, Newton and Constantine Huyghens were afterwards enabled to establish the most complete theories of all the planetary motions.

The discoveries of Newton with reference to the laws of gravitation have already been

adverted to; and we may add that from the time of our illustrious countryman, who carried the theoretical part of the science to its present state of perfection, astronomy has never been without an illustrious phalanx of supporters, whose particular discoveries are fully illustrated in the various articles relating to the science of astronomy.

Practical astronomy, to which we must now more particularly direct our attention, appears to have originated in Chaldea; but it found still more active supporters in the Arabian caliphs, and the philosophers who surrounded their courts. The caliph Almanza employed many able mechanics in the construction of instruments for his own astronomical observations; and he was so well provided with apparatus as to be enabled to measure, with tolerable accuracy, an arc of the meridian. Ulug Beg, grandson of the celebrated Tamerlane, was a great proficient in practical astronomy: he is said to have had very large instruments for making his observations, particularly a quadrant as high as the church of Sancta Sophia at Constantinople. But the practical mechanics of the east is, like their political institutions, of a very enduring character; and we still find their astronomical apparatus both accurate and colossal. The celebrated observatory at Benares still exists an enduring monument of the learning and mathematical science of the east; and we furnish our readers with a characteristic sketch of its appearance when visited by Sir Robert Barker.*



The earliest observatory of any importance, established in Europe, was erected by the

* Sir Robert says, when speaking of the edifice, "We entered this building, and went up a staircase to the top of a part of it, near the river Ganges, that led to a large terrace, where, to my surprise and satisfaction, I saw a number of instruments yet remaining in the best preservation, stupendously large, immovable from the spot, and built of stone, some of them being upwards of twenty feet in height; and, though they were said to have been erected many hundred years before, the gradations and divisions of the several arcs appeared as well cut, and as accurately divided, as if they had been the performance of a modern artist. The execution in the construction of these instruments exhibited a mathematical exactness in the fixing, bearing, and fitting of the several parts, in the necessary and sufficient supports to the very large stones that compose them, and in joining and fastening them into each other by means of lead and iron cramps. The situation of the two large quadrants, whose radius is nine feet two inches, by being at right angles with a gnomon at twenty-five degrees elevation, are thrown into such an oblique situation as to render them the most difficult, not only to construct of such a magnitude, but to secure in the position for so long a period, and affords a striking instance of the ability of the architect in their construction; for, by the shadow of the gnomon thrown on the quadrants, they do not appear to have altered in the least from their original position; and so true is the line of the gnomon that, by applying the eye to a small iron ring of an inch diameter at one end, the sight is carried through three others of the same dimensions, at the extremity of the other end, distant thirty-eight feet eight inches, without obstruction; such is the firmness and art with which this instrument has been erected."

landgrave of Hesse-Cassel, in 1561. It occupied the whole upper portion of his palace, and it was well furnished with astronomical instruments. Tycho Brahe, who was engaged about the same period in astronomical observations, very materially improved on the landgrave's apparatus, and made a quadrant capable of showing single minutes. He afterwards erected an observatory in the island of Huenna; it was of a square form, and provided with two lofty round towers. The instruments consisted of quadrants, sextants, circles, astrolabes, globes, clocks, and sun-dials. These instruments were so divided as to show single minutes; and in some the arc was so divided as to be read off into ten seconds. Most of the divisions were diagonal; but he had one quadrant so divided as to form forty-seven concentric circles. The whole expense attendant on the erection of his observatory is said to have amounted to 200,000 crowns.

In 1671 the royal observatory at Paris was finished, and the use of it assigned to M. Cassini, after it had been furnished with instruments at a very great expense. The erection of the Greenwich observatory, five years afterwards, may be said to form an era in practical astronomy. Mr. Flamstead was appointed the first astronomer royal, and the office has since been held by several distinguished mathematicians. In the beginning of the last century the practice of astronomy made but little progress, in consequence of the imperfect apparatus employed; but since that period the names of Hooke, Graham, Bird, Dolland, Ramsden, Troughton, and Herschel, as practical artisans, give abundant warrantry for the assertion that the natives of this country exceed those of all others in the construction of astronomical instruments.

The art of *navigation* is closely connected with astronomy, and as such will next engage our attention. Its origin, like that of most other arts, is involved in the fabulous history of early times; but, according to the accounts of the most ancient historians, it was in the Mediterranean and Arabian gulfs that the first attempts were made in the art, as in those places commerce assumed an active character in the intercourse between the Egyptians and Phœnicians. The former, who lived in a fertile land and a genial climate, which rendered them independent of the productions of other countries, devoted themselves to the cultivation of the sciences rather than that of commerce, and, imbued with gross superstition, applied only a portion of their knowledge of astronomy to navigation. But the Phœnicians, whose country was unequalled in its beauty, less superstitious, and of a more active and commercial disposition, boldly extended their voyages, and established their colonies nearly in every country that was known. They improved the construction of their vessels; they forwarded navigation as much as the period admitted; and they became the teachers of this art to all nations, particularly to the Gaditanos (inhabitants of Cadiz) and the Greeks. The Carthaginians and Romans succeeded them; but, although each in their turn improved their ships, the knowledge, geography, and navigation, limited to the mere performance of short voyages, would have remained in its infancy, had not the progress of mathematics, and particularly that of astronomy, in modern ages, roused it from its lethargic condition. Navigation at that period consisted only in the knowledge of coasts, and in making short voyages from one place to another, without losing sight of the land; and when, by any unforeseen accident this became invisible, the motions of circum-polar stars, and the flight of birds, naturally directed towards the shore, served as guides to the bewildered mariner. The configuration of coasts, and their mountains and principal headlands, with the use of the lead, formed another species of knowledge, for which the mariner was indebted to his experience in navigation.*

* Until the properties of the magnet were discovered, followed by the invention of the compass, the progress of navigation could not be otherwise than slow; and therefore, from this important period, which was about the end of the thirteenth century, the real advancement of this art towards perfection can only be dated. The valuable invention of the compass is equally involved in mystery, and its real discoverer is unknown.

"But little avail would it be to the mariner," says Salazar, "to know the course which his vessel may make with respect to the shore; or the means of measuring the distance she might sail, unless he possessed some method of comparing his situation with reference to the various parts of the earth's surface, when alone and forsaken in the vast watery desert, where the eye can discover only sea and sky. In this condition, astronomy is ready to assist him, and to afford him the means by which his latitude and longitude may be ascertained, and with these data he finds out the position he occupies on the globe. But even this is insufficient to enable him to shape his course in his lonely situation, surrounded on all sides by the element alone in which his vessel moves, nor can he yet direct her to the port he is seeking, or avoid the dangers he may meet in his way. The mariner, unless he knows the relative situation of the place to which he would go, must still be at a loss what to do; and, to ascertain this, he must be informed of the contour and direction of coasts, their respective positions, the motions of the tides and currents, the gulfs and depths of the sea, as well as the innumerable rocks with which it is scattered. Such are the important objects which constitute hydrography, all of which are essential to his safety and convenience.

The exact epoch is not known, with any probable degree of certainty, when seamen first made use of maritime charts, the ingenious invention and valuable guides with which geography has furnished navigation, and which, being gradually improved, have now arrived at that state of perfection which enables the navigator to traverse the ocean with the same confidence that a traveller would perform his journey across a country.

The celebrated prince Henry of Portugal, seeing the importance of advancing this branch of navigation, in the year 1417, founded an academy for pilots and mathematicians at Sagres, and established as the president of it *Maestro Jayme*, an experienced pilot of Majorca, one who was well acquainted with such matters. This person instructed young Portuguese officers in the use of the astrolabe, and the method of finding the latitude by means of the sun's altitude, having previously constructed tables of declination.

Hutton, in his *Mathematical Dictionary*, says that Ptolemy was the first to whom the idea occurred of varying the proportion of the degrees of latitude, and that Gerard Mercator, in 1556, published charts on the principle of those which now bear his name; but that Edward Wright was the first who conceived the true principles of constructing these charts in 1599, and that Mr. Blundeville published an account of Wright's charts in 1594. Such was the state of navigation at the end of the fifteenth century, when Columbus, well versed in the astronomical and mathematical knowledge of his day, and endowed with an extraordinary degree of intrepidity, boldly ventured across the ocean, traversed unknown seas, and, by discovering new countries, produced a total change in politics and science. In his first celebrated voyage, he discovered the variation of the needle, a phenomenon which, to his companions, appeared so wonderful, that, fearful of its losing altogether the virtue of pointing to the north, they imagined they must become victims to the ambition of this great man. But the safety of the navigator was yet imperfect, and a method was still wanted by which he might find his longitude at sea, and which, although it might not arrive at that degree of precision by which the course of a vessel could be found, should at least afford an approximation

Lafiteau, in his *History of the Portuguese Discoveries in the New World*, says that Vasco di Gama brought it to Lisbon from the coast of Africa, on his return from Melinda, where the Arabs then used it, and he believed the Portuguese to have been then ignorant of it. Some attribute it to Flavio Gioja, of Amalphi, about the year 1302; while others again are of opinion that the invention is due to the Chinese, and that one of their emperors, a celebrated astronomer, was acquainted with it 1120 years before the Christian era; nor have others again been wanting who have supported the opinion that it was known in the time of Solomon. The ancient Greeks and Romans are supposed by some to have used it, but the silence of Pliny on this subject renders this doubtful.

to it. For this purpose, various methods were proposed, all grossly defective, until astronomy again came to the aid of navigation. Hipparchus, the inventor of the use of longitude in charts, was acquainted with no other method of finding it than by eclipses of the moon. Kepler added those of the sun, at the expense of a vast deal of calculation; but, as each required that the observer should remain stationary, their methods were of no service to the navigator. The first person to whom it occurred to find the longitude by means of lunar distances was Pedro Apiano, in the year 1510; but his method was neglected, because it was deficient of the necessary corrections for parallax and refraction, in consequence of which it gave results that were even more erroneous than those obtained only by estimation. His contemporary, Reynero Gemma, adopted the same method, but fell into similar errors. To remove these difficulties, Philip III., in 1598, was the first to offer a considerable reward to the person who should discover a method of finding the longitude at sea that would not only serve to determine the situation of the ship, but would also improve the state of the charts. The Dutch government next followed this example, and in 1714 the British government voted 2000*l.* to perform experiments, and a reward of 10,000*l.* to the person who should find a method of ascertaining it within one degree of the truth; also 15,000*l.* if it came within two-thirds of it, and 20,000*l.* should it come within half a degree; but if the method employed was that of the distance between the moon and sun, or stars, 5000*l.* were offered to bring it within fifteen minutes of error in the distance, which is equal to seven minutes of longitude. With these encouragements, men of science applied themselves to gain the promised reward in Spain, France, and in England, as well as in other parts of the world. They invented various instruments and methods; but the results obtained did not fall within the proposed limits. The application of Jupiter's satellites by Galileo, previous to this, for determining the longitude, was more effectual; but these observations, so valuable for places on land, were unavailable at sea. The Spanish pilot, Andres de San Martin, in the voyage which he made with Magellan, had already employed the method with which Ruy Fallero had supplied him, of determining the longitude by lunar distances; but the results he obtained not being, as he considered, correct, with much discernment he attributed it to errors in the tables of the sun given in the almanac, satisfying himself that while they remained so the problem would never be determined. At the end of this century, Pedro Sarmiento de Gamboa, one of the most expert navigators of his day, obtained the longitude at sea by the lunar distances, which he measured with an instrument of his own making, and his results were so good that he was enabled to correct the reckoning of his ship, which he ascertained amounted to 220 leagues of error. But his invention was lost, as he did not make it known.

Gemma Frisius is the first who mentions the use of time-keepers; and, in 1665, a very interesting attempt was made to apply them in a voyage to the coast of Guinea, by major Holms, with a watch made by Huyghens. With this the longitude of the island of Fogo was obtained with tolerable precision. Tully followed up the art, and, in 1714, published a work on finding the longitude at sea by means of chronometers, and continued his studies at Paris. Julian le Roy was his pupil; and the son of this latter and M. Berthoud carried on the subject with more success than had hitherto been known. In 1726 Mr. Harrison produced a chronometer the error of which did not amount to one second in the space of ten years. Further improvements were subsequently made by the same ingenious artist, as well as by Earnshaw, Vulliamy, &c.; and the time-piece is now employed with great advantage for nautical purposes.

The true principles of the art of navigation appear to have been settled by Wright, Bond, and Norwood; and the subsequent discoveries of Cook and the other voyagers, who were so warmly patronized by George III., formed a distinct era in this branch of science. The voyages of discovery lately undertaken to the polar regions have also furnished con-

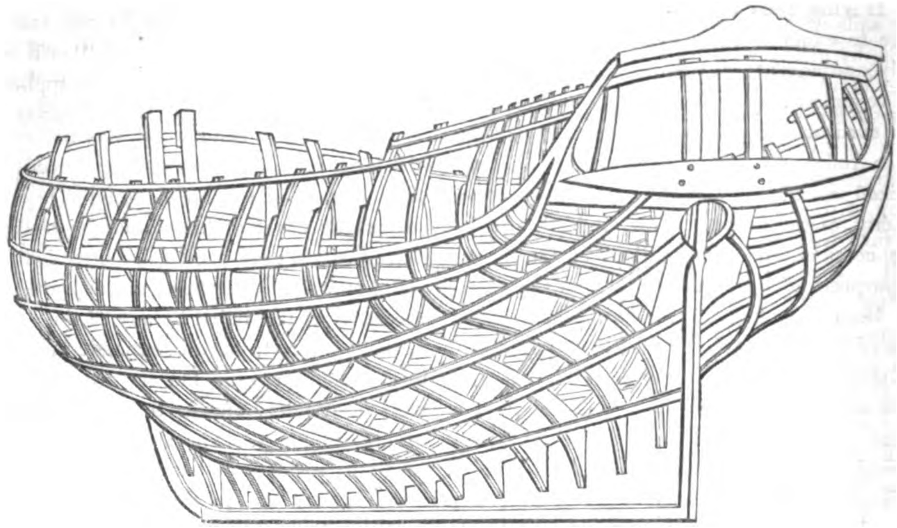
siderable advantages both to the practical and theoretical navigator; so that the sailor is now enabled to calculate with amazing precision, not only the probable effects of winds and currents on his course, but to predict with accuracy the day, and almost the hour, when his voyage will be terminated.

Having thus traced the progress of navigation from its earliest dawn, we may briefly pause to examine the vessels that have been employed at different periods for carrying the hardy and adventurous mariner over the trackless ocean. There is little doubt but that the first voyagers employed the trunk of a tree, which was afterwards expanded into a raft, for their earliest essays in navigation. Soon, however, the mass of solid wood was hollowed into a rude and mis-shapen canoe; and at a still later period the wants introduced by civilized society rendered it necessary to increase the freight, and consequently the capacity, of the vessel. Now, indeed, the business of the naval architect may be said to have commenced. The galleys of Greece and Rome, which were principally intended for the purposes of war, were formed on the most graceful and elegant models, and appeared to have been propelled with a degree of velocity scarcely to be paralleled by any of the war-boats of the present day. But little progress, however, appears to have been made in naval architecture by the commercial nations who rose in the middle ages. The huge carracks of Spain and Portugal, like the well-freighted argoseis of Venice, appear to have been intended rather for convenience of freight than external adornment. The ships of war were evidently moulded on the same plan; but vastness still appears to have been the great desideratum. The "Great Harry" was a perfect monster of the deep; its forecastle towered over the element on which it floated; and it was fitter for a floating battery than a sailing vessel. The English war-ships of that period were generally employed for commercial purposes and long voyages; while the greater part of the Spanish vessels, destined to compose the Armada, were mainly such as we have now been describing. Hence the greater facility which the English found in manœuvering their vessels, to which the destruction of the Spanish flotilla may be principally ascribed.—Passing over a period of nearly three centuries, we find but little progress made in naval architecture; and it is to the French and Germans, proverbially the worst sailors in Europe, that we must ascribe the first attempt at applying mathematical science to ship-building. Louis XVI. patronized naval science; and Napoleon established a college for the education of a race of scientific shipwrights. In our own country but little was done prior to the improvements introduced by Seppings, whose labours are fully detailed in the article NAVAL ARCHITECTURE.

One of the most curious features in connection with naval architecture is the speed with which a large vessel is now constructed. A few months will suffice to convert the tall and majestic oak of the forest into a portion of the frame-work and timbers of a large vessel. The iron and the copper, which lie buried deep in the bowels of the earth, are as rapidly raised to its surface, and converted into the sheathing and bolts, which connect together the huge structure. The hemp and the flax, which are seen as waving ornaments in our fields, become connecting chains to attach the bark to the bed of the ocean; and the tar sealed up in the heart of the lofty pine serves to lubricate its elastic coils. The vessel thus rapidly, yet perfectly formed, obeys each command of the mariner; goes before the wind, and almost against it; and forms for him a secure and stable mansion, in the midst of the most stormy ocean.

The frame-work of a ship furnishes a beautiful example of strength, durability, and lightness, and, when we bear in mind the massive and precious freights that are brought from the most distant regions of the earth in their capacious receptacles, it will be obvious that no ordinary care should be bestowed on their construction. The theoretical shipwright, pursuing the best of all possible paths, has evidently gone to nature for his guide in giving

strength to the superstructure. He has combined the osseous frame-work of the bird with the lightness and power of motion exhibited by the fish; but this miracle of human art must be stripped of her outer cerements to be properly appreciated, and in this form we present her to the reader in the subjoined engraving.

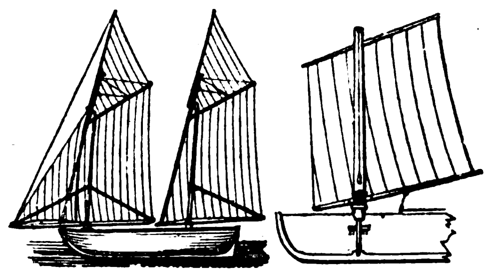


It is clear that the stability of the vessel will in a great measure depend upon the weight and position of her keel, which is usually so formed as to give the preponderance to that side of the vessel. In some modern improvements the keel is made movable, so that it will ascend and descend precisely in the same way as the feet of a bird are elevated and depressed, when flying through the air, and this forms a beautiful example of the adaptation of a natural action to an artificial structure. The rounded and expanded bow is as well fitted for the conveyance of freight as it is for speed; whilst the helm, acting like the tail of the fish, serves to guide the body in any required direction. The inhabitants of the air, like those of the waters, are usually provided with a smooth external covering, to facilitate their passage through the fluids they respectively inhabit. The sheathing of a ship answers a similar purpose; and Sir Humphry Davy has beautifully applied the principles of chemical science to its protection when exposed to the action of sea-water.

Passing from the hull of the vessel to the means by which she is propelled, we find but few early attempts to construct standing rigging. In some of the sculptured representations of Egyptian vessels, we find a mast and flag, though a sail is but rarely delineated. Even in the best days of Greece and Rome, the oar was generally employed both for commercial and military purposes; and, when canvas was resorted to, it appears to have been attempted with fear and trembling. The paddle is still the ordinary instrument of propulsion with most savage nations, though a bamboo mast, and bark sail, are sometimes added.

The motion of a ship in the water is well known to depend on the action of the wind upon its sails, regulated by the direction of the helm. As the water is a resisting medium, and the bulk of the ship considerable, it thence follows that there is always a great resistance on the fore-part of the vessel; and, when this balances the moving force of the wind upon the sails, the ship may be said to have attained her utmost degree of velocity, and her motion is no longer accelerated. If the sails occupy too extended a space, and be raised too high above the centre of gravity of the vessel, the first gust of wind is liable to destroy the equilibrium, and upset the vessel. To prevent the danger which would result from this circumstance, the sails of a vessel are rendered movable. More or less canvas may thus be employed as oc-

casion requires; and, in the event of a hurricane, the whole of the canvas may be removed from the rigging. A very ingenious contrivance has been suggested in the present century for preserving the equilibrium of a vessel and her rigging. It consists in balancing the mast, which revolves on axes beneath the deck, so that when a sudden gust of wind acts upon the sails with a tendency to overset the vessel the hull remains nearly stationary, and the sails, by giving way, form a species of inclined plane for the wind to pass over. It will however be obvious that this plan is only fitted for small craft. Another contrivance applicable to somewhat larger vessels, and of a still later date, is represented in the subjoined wood-cut.



Lieutenant Shuldam proposes by this arrangement to materially diminish the labour of working the sails, by causing them to turn with the masts upon pivots in the hull. This may be effected either by the action of the wind upon the sails or by manual labour. One of the figures exhibits the principle applied to a boat, and the other to a larger vessel; but in the latter case it will be necessary to form the masts of four spars raised upon a cross piece at bottom, and united at top to a cap or mast-head, thus forming an open pyramidal mast.

The history of navigation would be obviously imperfect without some reference to the progress of the steam-boat as applied to nautical purposes. We can hardly conceive a more extraordinary monument of human ingenuity than a steam-boat—a mere hull, as it were, furnished with one of these potent prime movers, and breasting her way against both wind and tide. Our transatlantic brethren, who erroneously claim the credit of having invented the steam-boat, certainly have the merit of first employing it usefully on their vast inland waters.*

We might have observed in passing that the steam-boat was really invented by an ingenious mechanic named Jonathan Hulls, early in the eighteenth century. He proposed to employ the atmospheric steam-engine, acting on a large revolving paddle-wheel placed in the stern of the boat. But how different is the first dawn of this invention from its consummation in the present day! Darwin exclaimed, in the spirit of prophecy, long before steam-boats were employed,—

> Soon shall thine arm, unconquered steam, afar
> Drag the slow carriage, and impel the rapid car,
> Or on wide-waving wings expanded bear
> The flying chariot through the fields of air.

Little however could the ingenious philosopher, who thus poetically describes the advantages of the steam-engine, have contemplated all the importance of this discovery. In a commercial point of view it is second only to that of the ship itself, and, by rendering ineffective the attempts at naval aggression on the part of other nations, it bids fair to secure to us all the advantages of a secure and lasting peace.

* The earliest appearance of a steam-boat on the great river Hudson appears to have excited the most lively emotions of fear and dismay, and has been thus described by the biographer of Fulton :—"The first steam-boats used dry pine-wood for fuel, which invariably sent forth a column of ignited vapour and sparks, many feet above the flue. This uncommon light first attracted the attention of the crews of other vessels. Notwithstanding the wind and tide were adverse to its approach, they saw with astonishment that the vessel was rapidly coming towards them; and, when it came so near that the noise of the machinery and paddles was heard, the crew shrunk beneath their decks from the terrific sight, and left their vessels to go on shore; while others prostrated themselves, and besought Providence to protect them from the approaches of the horrible monster which was marching on the tides, and lighting its path by the fires which it vomited."

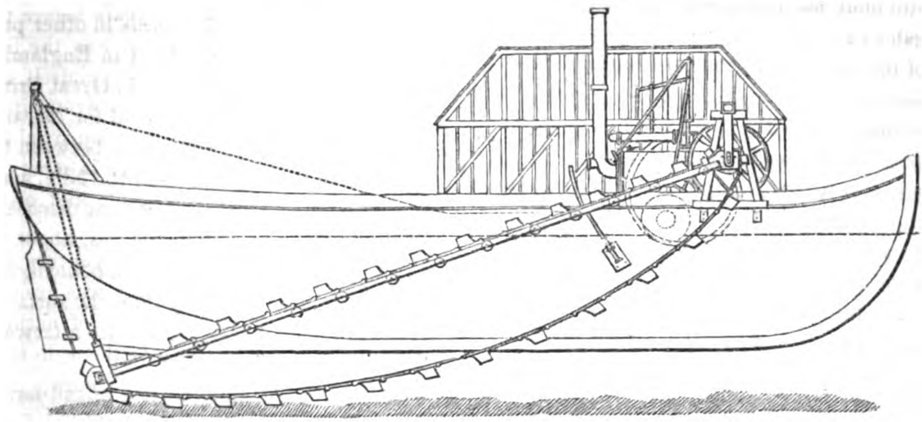
The *inland navigation* of this country has made an amazing progress since the commencement of the present century; and its effects are equalled only by those produced by the still more modern improvements of rail-roads. It was, however, in the middle ages that navigable canals began to be considerably multiplied; first in China, and afterwards in other parts of the world. The canal from the Trent to the Witham, which is the oldest in England, is said to have been dug in 1134. Now, however, almost every principal town in Great Britain is furnished with one or more of these fluid roads. Egypt has been celebrated for its canals from the earliest periods of history. The principal are the canal of Alexandria, between that city and Rosetta and the Nile, and parallel to it; and that of the Red Sea and the Nile, across the isthmus of Suez. The existence of this last, though a subject heretofore of some discussion, is now established beyond doubt. It was begun by Necho, son of Psammeticus, about 616 B. C., and the work was continued by Darius Hystaspes, but was afterwards abandoned, from fear of inundating a great part of Egypt, which was supposed to be lower than the surface of the Red Sea. The work was, however, resumed, and completed nearly a century afterwards, about 521 years before the Christian era, by Ptolemy II.

If we may believe the Chinese Annals, they must have had an extensive inland navigation at a period much earlier than any other country of the world. The only Chinese canal our space will permit as to notice forms part of the line of transportation between Pekin and Canton. Its route, including sinuosities, is said to exceed 500 miles. Italy holds a foremost rank in the march of improvement; and it was in that country that locks and sluices to pass boats from one level to another were first introduced. It was the invention of two engineers of Viterbo, brothers, whose names have not been recorded. This improvement was soon after adopted in the Milanese territory, under the direction of Leonardo da Vinci, the celebrated painter, who was also a skilful engineer. Inland navigation became so important that the Italian governments paid great attention to it, and enacted many regulations on the subject, and numerous treatises were published on the construction of locks, and the art of making and managing canals. The following are some of the principal canals of modern Italy:—The Naviglio Grande, between Milan and the river Tesina, fifteen miles in length, 130 French feet broad at the surface, and forty-six at the bottom. It was extended to Milan in 1257, and enlarged in 1269, with a branch of about eleven miles in length fpom Albiato southward. The Martesena canal branches off from the right bank of the Adda, near Contessa; is twenty-four miles in length and thirty-three feet in breath, and is raised in some places, by walls and embankments, 110 feet above the level of the river. In 1497, five locks were introduced into this canal.

Canal navigation has made considerable progress in France: indeed we believe at the present time they possess rather more than 1000 miles of artificial canals fitted for the navigation of boats. The first important work of the kind was the canal of Briare, completed in 1642; but the most extensive line of inland navigation in France is the canal of Languedoc, which forms a communication between the Mediterranean and the Atlantic Ocean. The first considerable work of this kind in our own country was executed by the duke of Bridgewater. This patriotic nobleman devoted the whole of his time and a large fortune to the project, and was rewarded by the most complete success. Our space will not, however, permit of any detailed account of the progress of canal navigation, which appears to offer commercial advantages second only to those of locomotion. It may be enough to add that there are in our own country more than 200 of these arterial ramifications, which benefit agriculture and spread happiness and fertility through their paths.

Canals and navigable rivers which tend seawards have usually a disposition to form bars, which speedily choke the mouth of the stream, and impair, if not destroy, the navigation. The ancients had no means of removing these barriers to commerce, and some of the oldest

harbours were of necessity abandoned from the circumstance. But the steam-engine, which may not unaptly be termed the "master-worker" of modern times, furnishes us with an effectual remedy for this inconvenience.



The ancient chaplet or bucket-pump is here seen put in operation by this gigantic prime-mover, and it digs and clears away the obstructing matter at a considerable depth beneath the surface of the water as freely as it would on land.* Now those who have witnessed the laborious operation of "ballast-heaving," as it is called, must at once feel the amazing advantages of this process. When conducted on a large scale, it costs considerably less than the old method, without outraging the feelings of humanity by a view of the almost super-human tasks inflicted on our fellow creatures by the former system.

Passing from the contemplation of the wonders of mechanical skill, as displayed in the artificial operation of fluid bodies, we come to examine the history of *anatomy*, and trace the progress of human knowledge in the most important of all the sciences. Man, in the earliest stages of society, must soon have acquired some notion of the structure of the animal frame, particularly of the external parts, and some even of the internal, such as the bones, joints, tendons, and blood-vessels, which are exposed to the examination of the senses in the living body. This rude species of knowledge was indeed gradually improved by the accidents to which frail mortality is exposed, both by the necessities of life, and the various customs and superstitions of different nations. Thus, the observance of bodies killed by violence, attention to wounded men in many diseases, the various ways of putting criminals to death, the funeral ceremonies, and a variety of occurrences, must have shown men more and more of themselves, and their own wonderful organization. This knowledge was, however, of a very general or popular character. Anatomy, properly so called, or the knowledge obtained by dissections, expressly instituted for that purpose, is of a more recent origin. It seems now to be clearly ascertained that writing, and many other useful and ornamental inventions and arts, were cultivated in the eastern parts of Asia long before the earliest times that they are treated of by the Greek or other European writers, and that the arts and learning of the east were, in subsequent ages, gradually communicated to adjacent nations, especially by the medium of traffic. The customs, superstitions, and climates of eastern countries appear, however, to have been as unfavourable to practical anatomy as they were inviting to the study of astronomy, geometry, poetry, and all the softer arts of peace. In warm climates,

* The harbour of Alexandria had become so choked by sand that it had almost become valueless for vessels of heavy burden. The present pacha applied to Mr. Galloway, the eminent engineer, for assistance in the matter, and he constructed two large machines, and, motion being given to them by oxen, the harbour was speedily restored to its original state.

animal bodies run so quickly into putrefaction that the early inhabitants must have avoided such offensive employments as were essential to anatomical enquiries; in fact, it does not appear, by the writings of the Grecians, Jews, or Phœnicians, that anatomy was particularly cultivated by any of those nations. Hippocrates, who lived about 400 years before the birth of Christ, was reckoned the eighteenth in descent from Æsculapius, and was the first physician who separated the professions of philosophy and physic and devoted himself exclusively to the latter pursuit, and is generally supposed to be the first who wrote upon anatomy. If, however, we read the works of this distinguished philosopher with impartiality, and apply his statement of the parts to what we now know of the human body, it must be allowed his descriptions are very imperfect, incorrect, sometimes extravagant, and often unintelligible.

From Hippocrates to Galen, who flourished towards the end of the second century, the decline of the Roman empire, that is, in the space of 600 years, anatomy was greatly improved, philosophers considering it as a most curious and interesting branch of natural knowledge, and the physicians as a principal foundation of their art. Both of them, in that interval of time, contributed daily to the common stock of knowledge, by more accurate and extended observations. Aristotle, a disciple of Plato, and preceptor to Alexander the Great, formed the most enlarged design which perhaps was ever conceived by man; no less than a general and detailed history of all nature, a plan by far too vast for the short life of any individual. The love of science, which distinguished Alexander the Great scarcely less than his ambition and thirst for glory, led him to encourage and assist the plans of Aristotle in a manner worthy of so great a prince. The sum of money devoted to his works on natural history would be almost incredible did we not consider the great resources and profuse liberality of Alexander, and was not this circumstance stated by writers of unexceptionable authority. Athenæus, Pliny, and Ælian, concur in representing it at between 100,000*l*. and 200,000*l*. Shortly after the foundation of Alexandria, a celebrated school was established there, to which the Greeks and other foreigners resorted for instruction, where physic and every branch of natural knowledge were taught. Herophilus and Erasistratus, two anatomists of this school, particularly celebrated in the history of anatomy, seem to have been the first who dissected the human body: for in the time of Aristotle animals only were dissected.

The Romans, in prosecuting their schemes of universal conquest and dominion, soon became acquainted with the Greeks, and the intercourse of the two nations was constantly increasing. Thus the arts, the philosophy, and the customs of the Greeks were introduced into Italy. Military glory and patriotism, which had formerly been the ruling passions of the Roman people, now began to give place to the more refined arts of peace; thus literature and philosophy were transported from the Greeks to the Romans, and gave rise to the taste and elegance of the Augustan age. In this way did conquered Greece triumph over the unpolished roughness of her conquerors. Galen, who was physician to four emperors, resided chiefly at Rome; he arranged all the prior anatomical science that Herophilus and Erasistratus had obtained from the actual dissection of human subjects, and incorporated it into his voluminous treatises on the different branches of medicine. The medical principles of this great man, formed on the peripatetic philosophy of Aristotle, are not to the present purpose, except that they reigned triumphantly in the schools and universities, disdaining and crushing all the innovators or improvers, for a period of nearly 1500 years. Galen was the first author who seems to have digested in regular order the human functions, the brain and its membranes, the senses, the contents of the thorax and abdomen, osteology, a complete myology, and neurology, in which are the origin and insertions of the muscles, their actions, &c., and the distribution of the whole nervous system. The lacteal vessels

were likewise well known, though the extent of their effects, their passing through the thoracic duct and subclavian vein to the blood, were not comprehended. Anatomy, however, experienced the same fate as learning in general, on the decline and fall of the Roman empire. The moral and intellectual character of the Romans had been much debased in the latter ages of the empire, and the successive irruptions of the northern barbarians accelerated the approaching fall. The inundation of the Goths into Italy, in the fifth century, extinguished with the Roman empire its laws, manners, and learning, and plunged the world into the depths of ignorance and superstition. The succeeding ten centuries, which have received the appellation of the dark ages of the world, presents a melancholy picture to the philosophical observer of human nature, a barren and dreary waste, unenlivened by a single trace of cultivation.

Among the circumstances which contributed to the restoration of anatomy is to be reckoned the assistance which it derived from the great painters and sculptors of the age. A knowledge of the anatomy of the surface of the body, at least, is essential to the prosecution of these arts. Michael Angelo dissected men and animals, in order to know the muscles which lie under the skin. A collection of anatomical drawings made by Leonardo da Vinci at this period is still extant, and, with subjoined explanations, formed part of the library of his late majesty. Dr. Hunter has borne witness to the minute and accurate knowledge which these sketches discover, and does not hesitate to consider Leonardo da Vinci as the best anatomist of his time. About the middle of the sixteenth century appeared Vesalius, who may with propriety be termed the restorer of anatomy, being the first who dared to expose the errors of Galen, in medicine and anatomy, by referring to the human body.*

Vesalius published in 1539, at the age of twenty-five, his grand work on *the structure of the human body*, with numerous elegant figures, supposed to have been drawn by the celebrated Titian. This work contains such a mass of new information, that it may justly be considered as forming an era in the history of anatomy.

Falopius comes next in order. He was a friend and pupil of Vesalius, and published a most extraordinary work on the same subject. The beginning of the seventeenth century is remarkable for the discovery of the most important function of animated bodies, viz. the circulation of the blood, by our celebrated countryman, Dr. William Harvey. In the year 1616, Dr. Harvey read a course of lectures, in which he first illustrated his views relating to the circulation of the blood, which some judicious anatomists had only conjectured to exist in a vague and confused manner, and had only known it to take place in some particular part. From this period, Harvey demonstrated and taught in his public lectures, and by simple and clear experiments proved to the most sceptical, that the blood not only traversed the structure of the lungs, but that it also circulated through every part of the body, by means of an admirable arrangement, on which depends the life of man. He fully illustrated the alternate contraction and dilatation of the heart, the passage of the blood through the lungs, its reception into the left auricle from the pulmonary veins, its expulsion from thence into the left ventricle, by which it is propelled through all the arteries of the body, and returned by the veins. So clearly were the phenomena of the whole circulation understood, and so admirably explained by Dr. Harvey, that, although he wrote two centuries ago, this function has never been laid down with more truth, simplicity, and elegance.

After the discovery and knowledge of the circulation of the blood, the next question

* He was born at Brussels, in 1514, and studied successively at the different universities of France and Italy. Thus he acquired all the knowledge of antiquity. Not content with this, he took every opportunity of examining the human body, and followed the army of the emperor Charles V. into France for that purpose in 1535. Vesalius was the first who maintained that dissection was the proper way of learning anatomy, in opposition to the study of the works of Galen.

would naturally be about the passage and route of the nutritious part of the food, or chyle, from the bowels to the blood-vessels. The name of Asellius, an Italian physician, is rendered illustrious by the discovery of the vessels which carry the chyle from the intestines. He observed them full of a white liquor in the mesentary of living animals, and from this circumstance called them milky or lacteal vessels. For many years the anatomists in all parts of Europe were daily opening living animals, either to see the lacteals or to observe the phenomena of the circulation. In making an experiment of this kind, Pecquet, in France, in the year 1651, was fortunate enough to discover the thoracic duct, or common trunk of all the lacteals, which conveys the chyle into the subclavian vein. And now the lacteals having been traced from the intestines to the thoracic duct, and that duct having been traced to its termination in a blood-vessel, the passage of the chyle was completely illustrated. The discovery of the absorbent vessels in various parts of the body, where they are known by the name of lymphatics, from the transparent colour of their contents, very soon followed that of the lacteals and thoracic duct. They were discovered in the year 1653. Rodbek, a Swede, is generally allowed to be the first who discovered these vessels; but this honour was disputed with him by Bartholin, a Dane, who has however obtained additional credit from his having entertained very accurate ideas of the physiology of the lymphatic system, which was afterwards more fully elucidated by Glisson. By these vessels the old particles of our bodies, which are no longer fit to remain in it, are removed and conveyed into the blood, to be rejected or thrown out by the excretory organs.

Leuenhoek took up the subject of anatomical enquiry where others had left it. He investigated the minute structure of the body by means of magnifying glasses, and was thereby enabled to demonstrate the circulation of the blood in the pellucid parts of living animals, and the red globules of the blood. Malpighi also directed his attention chiefly to the development of the more minute portions of the human structure, especially of the glands or secretory organs of the body. About this time anatomy made two great steps by the invention of injections, and the method of making anatomical preparations. For these we are indebted to the Dutch, particularly Swammerdam and Ruysch. The anatomists of former ages had no other knowledge of the blood-vessels than what they could collect from laborious dissections, and from examining the smaller branches of them on some fortunate occasion, when they were found more than commonly loaded with red blood. But filling the vascular system with a bright-coloured wax enables the anatomist to trace the large vessels with great ease, renders the smaller much more conspicuous, and makes thousands of the very minute ones visible, which, from their delicacy and the transparency of their natural contents, are otherwise imperceptible. The modern improved methods of preserving animal bodies, or parts of them, in spirits and saline solutions, has also been of the greatest service to anatomy, especially in saving the time and labour of the anatomist in the nicer dissections of the small parts of the body.*

It would occupy too much space to detail the labours and discoveries of all the eminent men who have distinguished themselves in anatomy during the last century. We may, however, state generally that every part of the human body has been most minutely and elabo-

* The act of parliament, which passed in 1832, for regulating the supply of subjects for dissection, and for legalizing the same, has been of the greatest importance; for, although the supply is still insufficient for the great number of pupils who annually resort to London for prosecuting their medical education, yet it has the following great advantages:—It prevents the recurrence of those dreadful murders which were perpetrated by Burke and Hare in Edinburgh, and by Bishop and Williams in the metropolis; and, secondly, it has removed the necessity of the anatomical professors and students being compelled to purchase subjects from the lowest and vilest of mankind. There are, however, many objections to some parts of the statute, which no doubt the executive will remove, when the necessity for doing so is pointed out.

rately examined and described, and accurate and elegant engravings have appeared of every part: so that a student of the present day possesses the greatest facilities for the prosecution of his anatomical labours. The bones and muscles have been most elaborately represented and described by Albinus, Cheselden, Cowper, John and Charles Bell, and Lizars. The vascular system has been illustrated by a splendid work of the baron Haller. Meckel of Berlin, and Scarpa at Pavia, and Sir Charles Bell in England, have bestowed equal or even superior diligence in tracing the distribution of the most important nerves, and faithfully delineating them. Dr. Cruikshank distinguished himself by an excellent work on the absorbent system; and Mascagni has given to the public a most elaborate account of the absorbent system, with splendid plates. Dr. Hunter, to whom anatomy owes more in this country than to any other individual, published a complete history, with beautiful explanatory engravings, of the growth of the human ovum. His brother, the late Mr. John Hunter, also deserves to be mentioned in this place, as an accurate and minute dissector, and a laborious experimentalist. He surveyed in his researches the whole field of animated nature, and greatly promoted the science of physiology. He formed also one of the grandest and most beautiful anatomical museums in Europe, which precious treasure passed into the possession of the Royal College of Surgeons. The next collection to John Hunter's was that of the late Joshua Brookes, which, to the disgrace of an enlightened country, was dispersed by the hammer of an auctioneer, although only 10,000*l.* was the sum required for a museum that had cost him forty years of devoted attention.

The structure of the brain has been represented with unrivalled elegance by Vicqd 'Azyr, a French anatomist. Some parts of this important organ have also been illustrated by the labours of Söemmering, who prosecuted the study of anatomy with unwearied industry. The splendid works of Jules Cloquet, now publishing by professor Quain, of the University of London, bids fair to be an invaluable addition to the student's library. The fine works of Sabatier, Winslow, Heister, Bichat, Weber, Automarchi, Tiedemann, Munro, Tuson, &c., are highly deserving the public attention, and it is to be lamented that their high price should preclude pupils generally from enjoying the advantages that must accrue from consulting them. The new doctrine promulgated by Drs. Gall and Spurzheim, under the title of *Phrenology*, has gained a considerable share of attention, and has been ably illustrated. We have from the hands of Söemmering two most finished productions in every respect on the anatomy of the eye and ear: but it would be unjust not to enumerate with a due tribute of applause the labours of Zinn, Scarpa, Lizars, and Dewhurst, on the same subjects. Morgagni, who taught anatomy in Padua, published a work of great utility on pathological anatomy. He has been followed in this country by the late Drs. Baillie and Armstrong; and it is but justice to state that the graphic illustrations attached to works of this character are very scientific and accurate.

Having said thus much respecting the history of anatomy, we shall now take a similar retrospect of the science of *medicine*. With regard to the early history of medicine, Schultze, professor at Altorf in the beginning of the eighteenth century, has traced it to the fall of man, showing with great gravity that Adam and Eve were likely to discover some remedial agents for the cure of those maladies which an indulgence of their appetites was likely to create. The most ancient physicians we read of were those who embalmed the patriarch Jacob, by command of his son Joseph. It is not improbable that among the Egyptians religion and medicine were originally combined; and most writers are of opinion that the priests were the physicians of both the Egyptians and the Israelites for a considerable period: but after the liberation of the latter they were disunited, and after that time the word *physician* is very commonly employed, and totally distinct from that of priest; for we read that when one of the kings of Israel was diseased in his feet, "he sought not the Lord, but

went to the physicians." Hence we may conclude that among the Jews medicine was looked on as a mere human invention. The Egyptians believed that the science of medicine was invested in Thoth, the Hermes or Mercury of the Greeks. His name is said to have been written on pillars in hieroglyphics, in order to perpetuate his knowledge. The Greeks also had several deities to whom they attributed the invention of physic, particularly Prometheus, Apollo, and Æsculapius, the latter being the most celebrated. If we may believe the ancient poets, the warriors were physicians also; for according to them the knowledge of medicine was universally diffused. Most of them received instruction from the centaur Chiron. From him Hercules is said to have obtained his knowledge of physic, in which he was no less expert than in deeds of arms.

The practice of the Greek physicians, notwithstanding the praises of their poets, appears to have been very limited, and often pernicious. A great many of their remedies consisted of charms, incantations, amulets, &c. In this way, then, medicine continued for many ages. Its first professors were ignorant of anatomy, and knew as little of the theory of diseases. It is plain therefore that whatever they did was mere random trials, or empiricism, in the strict and proper sense of the word. Among the Greeks, however, Æsculapius was considered the most eminent practitioner of his time, and his name was revered after his death. He was ranked among the gods, and the principal knowledge of the art remained in his family to the time of Hippocrates, who was one of his descendants. This physician is justly considered as the father of medicine. From his time, medicine, separated from religion and metaphysics, seems to have assumed the form of a science, and to be adopted as a profession. After the days of Hippocrates, the science gradually improved through other physicians, particularly Proxagoras, Eristratus, and Herophilus. The first physician of eminence who greatly differed from Hippocrates was Proxagoras; the next is Eristratus, who was a man of great talent, and flourished in the time of Seleneus. He was instructed by Chrysippus, who prohibited the use of aperients, emetics, and lavements; and, according to Galen, he banished venesection or bleeding from his practice. Others, however, affirm that he did not totally discard, but only employed it less frequently than his contemporaries. Herophilus was the first who properly knew the doctrine of the pulses, of which Hippocrates possessed but little knowledge—a branch of medical science of such vast importance that Dr. Rucco has published two large volumes replete with practical information on the subject. Herophilus also noticed the disease now known by the name of *anguina pectoris*, but which he called palsy of the heart; and to this it was that he ascribed certain hidden deaths. According to Celsus, medicine was at this period divided into three branches, viz. the dietetic, pharmaceutical, and chirurgical medicine. The first of these employed a proper regimen in the cure of diseases; the second, medicines as remedial agents; and the third, the operation of the hands; and from this time we may date the division of practitioners into physicians, apothecaries, and surgeons. Previous to this period, the physician performed all the duties of the other two classes.

Avicenna, who was born A.D. 1078, placed Arabian medicine at its height, and for a considerable length of time superseded the doctrines of Galen, which however ultimately revived. The cultivation of medicine in the western parts of the world commenced at Salerno, perhaps as early as the ninth century, but in 1143 and 1233 was finally established; and here medicine was taught according to the principles of the Greeks. The Galeno-Arabian science of medicine, which flourished during the middle ages, was mostly fostered by the monks, and only existed through ignorance and superstition. Mundinus, in the fourteenth century, by improving the study of anatomy, caused that of medicine to be better cultivated; and he describes the discovery of several new remedies, both foreign and domestic. The study of Greek literature was revived by the scholars who were driven from Greece by

the conquest of Constantinople in 1453, when the Greek medical writings were read in their original language, particularly Hippocrates. This caused a more scientific and liberal spirit of investigation to take the place of antiquated prejudices. Thus the ultimate fall of the Galenic system was prepared and completed in the sixteenth century, and forms the most essential part of the reformation accomplished by Paracelsus in 1526. The chemico-theosophical system of this enthusiast was refined and arranged by Van Helmont, who died in 1644, until deprived of its theosophical character it passed over into the chemico-material system of Franciscus Sylvius, who flourished about 1660, and at length into the peculiar views of Stahl. Dr. Frederick Hoffman methodized, if he did not originate, the dynamic system, from which all the dynamic schools of modern times have proceeded. The newest systems are those of M. Broussais, who traces all diseases to inflammation of the bowels, and of Dr. Samuel Hahneman, who denominates his doctrine homœopathy, the essential characters of which are that such remedies should be employed against any disease as in a healthy person would produce a similar but not precisely the same disease, and in the conviction that every malady carries with it a great susceptibility for the proper medicine, and that the power of medicine increases by minute division. The homœopathist gives but one drug at a time, and does not administer another dose of a new medicine until the first has taken effect; at the same time, a strict diet is prescribed, that the operation of the medicine shall not be disturbed. In the preceding sketch we have of course omitted all reference to the modern medical writers, as a bare enumeration of the titles of their works would form an extensive catalogue. But the labours of Cullen and Mason Goode have fortunately brought into one focus nearly the whole of modern medical science.

Surgery is that branch of the healing art which cures or prevents diseases by the application of the hand. War early made the healing of wounds more important than the curing of diseases, which were then less frequent, on account of the simple manner of living. In the time of Hippocrates, lithotomy was forbidden to be performed by the physicians. The Arabians likewise felt an aversion to operations, and it was considered beneath the dignity of the physicians to operate themselves. In the middle ages, the practice of the healing art was almost entirely confined to the priests and monks. But in 1163 the Council of Tours prohibited the clergy, who then shared with the Jews the practice of medicine in Christian Europe, from performing any bloody operation. Surgery was banished from the universities under the pretext that the church detested all bloodshed; consequently the useful sciences of medicine and surgery became separated from each other. The separation was the more easily effected since the bath-keepers and barbers had undertaken the practice of surgery. In France the company of barbers was formed in 1096, when William, then archbishop of Rouen, prohibited the wearing of the beard. These bath-keepers and barbers remained for several centuries in possession of the practice of surgery. Meanwhile the mists of the middle ages gradually disappeared. Enlightened by the science of anatomy, surgery began to assume a new and brilliant position, and the productions of Berengario de' Carpi, of Fallopius, of Eustachius, &c., were the true sources of knowledge from whence Ambrose Paré enriched this science, which had been previously degraded by its unison with the trade of a barber, but in this country the appellation of barber-surgeon continued until the establishment of the Royal College of Surgeons by charter, granted by George III., when this unscientific union was dissolved. By the important discoveries of Fabricius, Wiseman, and Dr. William Harvey, surgery made a very rapid progress. In 1731 the Academy of Surgery was established in France, and soon became celebrated throughout Europe. The Maréchal la Peyronie, Lamartiniere, &c., were distinguished surgeons. The collection of memoirs and prize writings of this academy contains the history of this flourishing period. There are preserved the labours of I. L. Petit, Lafage, Le Cat, Sabatier, and many other eminent practitioners. At this period flourished in Ger-

many and the north of Europe Heister, Zach, Platner, Roderer, Theder, and Richter. In Holland, Albinus, Deventer, and Camper; in Italy, Molinelli and Moscati; in Great Britain, Cheselden, who was celebrated as a successful lithotomist, Douglas, the two Munros, Sharp, Alanson, Smellie and Percival Pott of St. Bartholomew's Hospital, Cline, and Abernethy. At the present day we have, besides Sir William Blizard, who has justly been considered as the father of modern surgery, Sir Astley Cooper, Sir Benjamin Brodie, Mr. Lawrence, Mr. Guthrie, and Sir Charles Bell, and many of these gentlemen are the authors of productions that are a credit to the age we live in. Our space does not permit of our pursuing the subject further; but it must be obvious that now surgery goes hand in hand with medicine, and is supported by minute anatomical knowledge, it must advance rapidly towards perfection.

Chemistry is the handmaid of medicine no less than the domestic arts; a brief history of the progress of this branch of knowledge is therefore essential to the plan we have sketched out. Chemical research is indeed a most delightful employment; and, as we have already had occasion to state, it in no shape involves the necessity of purchasing costly apparatus. Experimental data perfectly illustrative of the science may be procured by the simplest means, and with almost as much certainty as in the various branches of mechanical science. In this respect the moderns enjoy amazing advantages over the ancient alchemists. They laboured with a degree of incertitude equalled only by the followers of the occult art, and at a period when sober utilitarian science would have had but few followers. But, however vague and visionary we may consider the labours of the early alchemists, they certainly have the merit of having invented much of the chemical apparatus we now employ. To render our sketch, therefore, of the history of chemistry intelligible to the reader, it will be necessary for us to trace somewhat in detail the labours of these amusing visionaries.

Passing by the first dawn of alchemy, which evidently commenced at a very early period, we find the art formed into a regular code of knowledge, under the patronage of the Gothic king Alonzo. In the *Libro del Tesora*, written by that monarch, he states, with an appearance of great devotion and humility, that, although he had not wished for the philosopher's stone, yet the gift was bestowed upon him, that he might defend the kingdoms of his fathers. "In secrecy," he says, "I was instructed in this inestimable treasure, and therewith did I increase my wealth." It would have been fortunate if he could have employed this power in the season of distress; for letters are extant in which king Alonzo solicits alms; and at a prior period he actually pawned his crown jewels to the governor of Morocco. The fancied treasure of Alonzo was guarded with much jealousy. A copy is extant in the royal library of Madrid, bound in boards of massy oak. The manuscript was locked with an iron lock, a circumstance from whence it also obtained the name of the *Libro del Candado*. This precaution, however, seems to have been needless; for all the efficient lessons of the art were written in secret characters, so that the opening of the volume is of little service, even to the "good and the wise," for whose profit Alonzo wishes to reserve the exposition of the secret, which he was also equally anxious to conceal from the profane. The cipher employed by Alonzo indicates the source of his knowledge. His alphabet appears to be a current Cuphic character, or rather that modification of the Cuphic which is still used by the Occidental or Mauritanian Arabs, but the letters are varied by points and flourishes; they are probably not employed according to their original powers; and it appears from the table or key at the end of the Madrid manuscript that each letter of the Roman alphabet has ten or twelve corresponding signs in the secret character.*

*By the common consent of the ancient writers we are taught to consider Egypt as the parent land of alchemical science. Perhaps some of the numerous symbols which the astronomer employed in common with the alchemist, if not truly Egyptian hieroglyphics, may at least be reminiscences or imitations of the sacred character. The signs denoting the seven planets are unquestionably of high antiquity, and figures

In the thirteenth century, Albertus Magnus, Roger Bacon, and Raymond Lully, seem to have been the great stars of alchemy, which they raised to a degree of credit somewhat beyond its merits. The alchemists, however, still endeavoured to veil the terms as well as the principles of their art under mystical characters. That the alchemist possessed a certain portion of useful knowledge cannot be doubted. Mr. Brande, who has ably traced the history of chemistry from its rude and expirical origin until the present era, says that the works ascribed to Geber contain matter that well justifies the praise of Boerhaave, who considers him as a first-rate philosopher of his age. But the secrecy which the alchemists affected repelled improvement, and almost every discovery died with its inventor. Until the "Triumphant Chariot of Antimony" rolled forth, and the bold but credulous physicians of the sixteenth and seventeenth centuries borrowed the powerful materia medica which they found in the laboratory, by which they discomfited the followers of Galen, the chemistry of Hermes had scarce produced any practical benefit in the higher pursuits of science, and the assistance which some of its preparations afforded to a few branches of the arts was accomplished rather by accident than by intention." Mr. Brande observes that "the transmutation of baser metals into gold and silver, which was the chief, and, in most cases, the only object of the genuine alchemists, was not merely regarded as possible, but believed to have been performed, by some of the more enlightened chemists of the seventeenth century; and in perusing the history of these transmutations as recorded by Helvetius, Boerhaave, Boyle, and other sober-minded men, it would be difficult to resist the evidence adduced without the aid of modern science. Lord Bacon's sound sense has been arraigned for his belief in alchemy, although he in fact rather urges the possibility than the probability of transmutation; and, considering the infant state of the experimental sciences, and of chemistry in particular, in his age, and the plausible exterior of the phenomena that the chemists were able to produce, he is rather to be considered as sceptical then credulous upon many of the points which he discusses. Some of the narratives of the effects of transmutation are indeed of a most extraordinary character. Helvetius positively affirms that he converted half an ounce of lead into pure gold, the materials for which were furnished him by an artist named Elias. The alchemist who arranged the process is said to have been absent when the experiment was made, which however succeeded so perfectly that the precious metal made from the lead was worth twenty-five florins.

Frederick III., emperor of Germany, is said to have caused a medal to be struck of the gold produced by an alchemical operation, which was performed in his presence by an alchemist of the name of Richterhausen. Frederick was so well satisfied with the result that he granted letters of nobility to the adept, and called him up amongst the barons of the Holy Roman Empire by the appropriate style of "Baron of Chaos." Such a fief was worth a fortune, and accordingly, wherever he went, the baron of Chaos met with capital success. At the court of the elector of Mayence he offered to effect a transmutation, for which purpose he produced a small portion of the matter of projection, in size and shape like a lentil. The powder had been mixed up with gum tragacanth, for the purpose, as he said, of binding it, and then again the pellet was enveloped in wax. The elector was desired to put it, together with four ounces of quicksilver, in a crucible, which was afterwards covered with charcoal. The elector and the

resembling them, though they may not bear the same signification, are found on Egyptian monuments. Alchemical symbols are discovered in the sacred edifices of the middle ages; and their appearance need not excite surprise, notwithstanding the seeming incongruity of their position, as alchemy was then considered the most pure and holy art vouchsafed to man by the benignity of Providence. It was a favourite study of the clergy; and a numerous and venerable cohort of adepts might be assembled from the cloister and the cathedral. The consecrated walls and the storied window have displayed the symbols of the magistery and the elixir; and the blue lion and green lion, the red man and the white woman, the toad, the crow, the dragon, and the panther, all alchemical signs, were blended with the legends of the saints and martyrs.

baron of Chaos then blew the fire vigorously, and at the expiration of half an hour the crucible was taken from the furnace, and the baron poured out the molten gold. The liquid metal appeared of a bright red, and the baron exclaimed that its touch was too high—it must be lowered by the addition of silver. The elector threw in a bar of silver, and after a second fusion the metal was cast in an ingot. It was very pure, but rather brittle. The baron of Chaos easily accounted for this defect, as he said that "some particles of tin had probably adhered to the ingot mould, but a third fusion would remove the alloy." This was done at the mint, and the gold then became exceedingly ductile, and the mint-master told his serene highness "that he had never seen such fine gold, and that its touch was more than twenty-four carats." Monconnis tells the story in the words of the elector, and it is evident that both of them believed that a real transmutation had actually taken place.

Less fortunate than the baron of Chaos was an alchemist of the name of John Henry Muller, who originally practised as a barber in Alsace, his native province. The court of the emperor Rodolph, a munificent patron of the occult sciences, offered great temptations to adventurers of this description, and Muller's management of the emperor was so satisfactory that he obtained large presents. He was exalted into the caste of nobility, and his humble surname of Muller, or Miller, was judiciously expanded into the title of "Baron of Muhlenfels." After may adventures, the baron arrived at Stuttgard. Duke Frederick of Wirtemburg was as ardent an alchemist as the emperor, and the baron performed many transmutations with great success. The duke poured the metals into the crucible, the doors of the laboratory were locked and sealed, and on the following morning the amalgam of lead and mercury was found richly impregnated with gold. Another operation performed in the castle of Reidlingen had the same result. It appears that the baron of Muhlenfels was enabled to effect the first transmutation by the help of a confederate concealed in a chest which was supposed to contain chemical apparatus; and at Reidlingen the same useful agent found his way through a vault. But the baron was not allowed to enjoy his credit in peace; for now the far-famed Sandivogius made his appearance at Stuttgard. He was really a Polish nobleman, and universally considered as the greatest alchemist and magician of the age. The two adepts were placed in a dramatic situation, which would be ludicrous enough were it not for the catastrophe. The baron of Muhlenfels was a credulous rogue, and, conscious that he was an impostor, he was dreadfully perplexed by the presence of a rival whom he verily believed to be a true master of the occult sciences. By insinuating to Sandivogius (whose conscience was probably not very clear, and who seems to have been equally apprehensive of coming in contact with any genuine sage) that the duke intended to put him to the torture for the purpose of obtaining the secret, the baron induced him to run away from Stuttgard. Muhlenfels then contrived to arrest the adept on his road, by virtue of a feigned order. Sandivogius was thrown into a dungeon by a village judge, and Muhlenfels took possession of his property, which was very considerable. The unlucky alchemist was nearly killed by the severities which the false brother inflicted upon him, in order to compel him to disclose the mysteries of the art; for, as we have observed before, Muhlenfels never doubted but that Sandivogius possessed the philosopher's stone. Sandivogius at length escaped from his prison, and accused the baron before the imperial tribunal; and Muhlenfels was found guilty of robbery, and condemned to die.

The old jurists had some difficulty in determining whether it was lawfully allowable to make money by alchemy. Baldus, a high authority amongst the civilians, gave his opinion that the practice was legal. Our common lawyers thought otherwise, and in the reign of Henry VI. an act was passed (according to lord Coke it is the shortest in the statute book) which ordains "that no one from henceforth shall use to *multiply* gold or silver, nor the craft of multiplication." Boyle is said to have procured the repeal of the prohibitory enactment,

on account of the impediments which it offered to the study of alchemy; but, by inspecting the petition upon which the act was founded, it appears that it was intended merely to repress the ingenuity of a most unphilosophical class of artists. The commons prayed that the practisers of the aforesaid art should, upon conviction, incur the punishment of felony; "because many persons, by colour of this multiplication, make false money, to the great discredit of the king, and the injury of his people."

It might be thought that the number who had lost their all in this absurd and visionary pursuit would have induced more correct and scientific views. Yet alchemy stood its ground and flourished; and the adept, though a felon by act of parliament, worked in peace, with unchanged hope and unwearied earnestness. All the sad experience which he obtained could never suffice for his instruction. Retorts burst, and crucibles are shivered in the process,—the alchemist's projection evaporates in smoke and fume; but the adept is not to be roused from his day-dream. Again he returns to the laboratory. He refils the alembic and the aludel; and the "Bath of Mary" is replenished anew. Salt, sulphur, and mercury are blended in proportionate measure, and once more the parched disciple of Geber watches the concoction of the tincture and the menstruum, whilst he nourishes the slow reverberating flames of the furnace. His diligence abates not with increasing age. Years roll on. The colours of the liquid change; it reflects the azure line, which gradually softens into the play of the opal, and at length the iridescent tints concentrate into the gleam of the orient ruby. Breathless and feverish, he hails the appearances which the mystic sages of the east have taught him to consider as the tokens that the great work is fast approaching to its consummation. He rejoices, and expects that his toils are about to terminate and the elixir is in his power. But at the very moment of joy he discovers again that fate denies the boon: and the transmutation is as ineffectual as when, young in spirit and in years, he first read the perplexed allegories in which he has so long placed his trust.

While the alchemist was thus deceiving himself, and by his example tending to lure others into the same visionary track, he was in reality most materially benefiting the cause of chemical science. The furnace of the adept was nearly identical with that of the chemist in the present day. The retorts, crucibles, and other instruments for manipulating in connection with the furnace were also similar in their character; and, though alchemists wanted the metal platinum for very high temperatures, their vessels must have possessed great power of resisting heat, as there are well recorded instances of their enduring the action of fire for many years without intermission.

The preparatory essays of the alchemist lead us to the history of chemistry, properly so called. This cannot be said to have existed as a science previous to the commencement of the seventeenth century. Its general principles may be acquired from the ordinary phenomena of nature as they exist around us; and it is truly extraordinary that so many persons, not uninformed in other respects, should remain ignorant of the constitution of bodies upon which their very existence may be said to depend. And it is but too true that even at the present moment there are numbers who have, generally speaking, received a liberal education, that still consider earth, air, fire, and water as the only elementary bodies.

The names of Bacon, Boyle, and Hooke stand foremost in the list of the early cultivators of chemistry. The last of these writers, in his *Micographia*, published in 1664, has sketched a beautiful theory of combustion, in which he dwells chiefly upon the influence and necessity of air to the process, and refers the power of supporting combustion to a principle existing in saltpetre. The following are the principal passages relating to this subject:—"From the experiment of charring of coals (whereby we see that, notwithstanding the great heat, and the duration of it, the solid parts of the wood remain, whilst they are preserved from the free action of the air, undissipated) we may learn

that which has not, that I know of, been published or hinted at, nay, not so much as thought of, by any; and that, in short, is this :—First, that the air in which we live, move, and breathe, and which encompasses very many, and cherishes most bodies it encompasses, that this air is the menstruum, or universal dissolvent of all sulphurous bodies. Secondly, that this action it performs not, till the body be first sufficiently heated, as we find it requisite also to the dissolution of many other bodies by several other menstruums. Thirdly, that this action of dissolution produces or generates a very great heat, and that which we call fire; and this is common also to many dissolutions of other bodies, made by menstruums, of which I could give multitudes of instances. Fourthly, that this action is performed with so much violence, and does so minutely act, and rapidly agitate the smallest parts of the combustible matter, that it produces, in the diaphanous medium of the air, the action or pulse of light; which what it is I have elsewhere already shown. Fifthly, that the dissolution of sulphureous bodies is made by a substance inherent, and mixed with the air, that is like, if not the very same, with that which is fixed in saltpetre, which, by multitudes of experiments that may be made with saltpetre, will, I think, most evidently be demonstrated."

Mayow, in 1674, appears to have thrown out a suggestion tending to show the existence of vital air as an agent in the process of combustion. Newton, to whom every branch of science owes a deep obligation, made two important contributions to chemistry. He subverted the ancient doctrine concerning the causes of chemicalaffinity; and, instead of referring the tendencies which bodies have to combine to the peculiar forms and attributes of their atoms, he referred it simply to the attractions belonging to their ultimate particles. His queries on this subject attached to his work on optics are so explicit and distinct as to be creditable even to the sagacity of Newton. To him we are also indebted for the discovery of a mode of graduating thermometers, so as to render them correspondent with each other; this was that real utility conferred upon the instrument, by which philosophers were afterwards enabled to carry on their researches in a very difficult department of chemistry with remarkable facility and precision.

In France, about the same period, we find Geoffroy, the two Lemerys, and Homberg, actively engaged in experimental pursuits. The last of these chemists is well known as the discoverer of pyrophorus. Beccher allowed the existence of five elementary substances: water, air, and a vitrifiable, an inflammable, and a mercurial earth; he considered acids as derived from the union of earth and water; stones as produced by the combination of two earths; and metals by the combination of the three earths in variable proportions. Beccher also added to the instruments of chemical research, and simplified many of the very complex operations then prevalent in the laboratory. As a practical chemist he is perfectly intelligible, but his theories are involved in so much contradiction and mystery that it is barely possible to understand the ends he aims at. He was succeeded by Stahl, whose name, as coupled with the once prevailing and generally received phlogistic theory, is familiar to chemists. Stahl's doctrines are perspicuously set forth in his *Fundamenta Chemicæ*, published at Nuremberg in 1723. He refers combustion to the separation of a highly subtile and elastic matter, which, under certain circumstances, is thrown into violent agitation, and then constitutes flame or fire: this principle he terms *phlogiston*. He asserts that when substances are burned they throw off *phlogiston*, and that, by its addition to the residuary matter, the original substance is reproduced; and endeavours to demonstrate this assertion by reference to the combustion of sulphur and some of the metals.

The discoveries of Dr. Black come next in order; and, whether with reference to their own value or their immediate influence upon other branches of chemistry, may be considered as forming an era in the science. His first experiments refer to the causticity of the earths and alkalies. It was long known that chalk, which is a mild insipid substance, after having been

made red hot, became converted into quick-lime, which is caustic and acrid; but the cause of this change, though it had been looked for by Macquer and others, remained unknown; it was generally referred to the absorption of fire. Black's attention was drawn to this subject by the discovery of magnesia, which, in 1720, was first distinguished from lime by the celebrated Hoffman, who also obtained it from sea-water. Dr. Black's researches led him to ascertain the existence of a peculiar aëriform matter in the mild earths and alkalies, which was driven off by heat and expelled by acids, and which he called *fixed air*.* But the enquiries which have generally been considered as the main foundation of Dr. Black's scientific eminence are those relating to the operation of heat in changing the states of bodies, as in converting solids into liquids and liquids into vapours.

Dr. Priestley's first written contribution to the cause of chemical science appeared in 1771; and two years later he fully explained the influence of vegetables upon the purity of the atmosphere. †

In 1774 Dr. Priestley procured oxygen gas from red lead. This he called "dephlogisticated air;" he also discovered several other gases. Five years afterwards, Bergman published his *Opuscula*, containing a variety of important essays on chemical subjects. He was succeeded by Scheele, who exhibited the results of a series of experiments on air and fire. Scheele discovered baryta, and ascertained the existence of nitrogen in ammonia; he also pointed out the mode of obtaining several acid bodies. Cavendish was the first who obtained hydrogen in its pure state; and, combining that gas with oxygen, he was enabled to produce a definite quantity of water. He also showed the constituents of nitric acid. About this period Lavoisier gave importance to the French school by the publication of his antiphlogistic theory. He endeavoured to prove that oxygen was of necessity present in every case of combustion. This doctrine, however, we now know to be erroneous. Guyton, Morveau, and Fourcroy, assisted him in his experimental investigations, and by their united labours materially improved the system of chemical nomenclature. We now arrive at a brilliant period in the history of chemistry. The labours of Sir Humphry Davy, Thomson, Ure, Henry, Leslie, Dalton, Wollaston, Brande, Philips, and Faraday, omitting the discoveries of the modern foreign chemists, would alone form a series of volumes; and we must content ourselves with a reference to the results of their labours as they are detailed in the various articles in the subsequent pages of this Cyclopædia.

A branch of chemistry which the French have altogether raised to the rank of a science, and which in this point of view is in a great measure their own, is *crystallography*. They were not indeed the first who discovered the tendency of certain minerals always to assume regular forms; but Romé de Lisle, and infinitely more the abbé Haüy, have deduced from this property such an admirable series of laws, and so beautiful a system of nature, that any

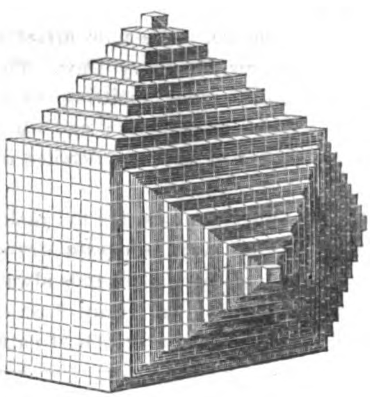
* It is a curious circumstance that Dr. Brownrig, in 1765, appears to have possessed a tolerable acquaintance with the nature of the choke-damp of the miners, as, in a paper read before the Royal Society, he pointed out the analogy which subsisted between that gas and the subtile principle of mineral waters.

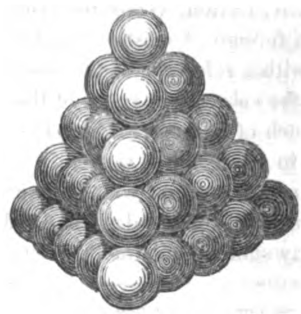
† The Royal Society voted Dr. Priestley the Copley medal for his paper on different kinds of air, read before the members; and the learned president thus illustrated one branch of the Doctor's observations:—"From these discoveries we are assured that no vegetable grows in vain, but that, from the oak of the forest to the grass of the field, every individual plant is serviceable to mankind, if not always distinguished by some private virtue, yet making a part of the whole which cleanses and purifies our atmosphere. In this the fragrant rose and deadly nightshade co-operate; nor are the herbage nor the woods that flourish in the most remote and unpeopled regions unprofitable to us, nor we to them, considering how constantly the winds convey to them our vitiated air, for our relief and for their nourishment. And, if ever these salutary gales rise to storms and hurricanes, let us still trace and revere the ways of a benificent Being, who, not in wrath, but in mercy, thus shakes the water and the air together, to bury in the deep those putrid and pestilential effluvia which the vegetables on the face of the earth had been insufficient to consume."

previous knowledge which others may have had of the more leading facts does not in the least diminish the credit of their discoveries.

It is commonly observed that crystalline bodies affect one form in preference to others. The fluor spar of Derbyshire crystallizes in cubes: so does common salt. Nitre assumes the form of a six-sided prism, and sulphate of magnesia that of a four-sided prism. These forms are liable to vary. Fluor spar and salt crystallize sometimes in the form of octohedra, and there are so many forms of carbonate of lime that it is difficult to select that which most commonly occurs. Romé de Lisle referred these variations of form to certain truncations of an invariable primitive nucleus; and Gahn afterwards observed that when a piece of calcareous spar was carefully broken all its particles were of a rhomboidal figure. This induced Bergman to suspect the existence of a primitive nucleus in all crystalline bodies. When Haüy entered this field of enquiry, he not only corroborated the opinions of Bergman, and submitted former hypotheses to experimental proof, but traced with much success the laws of crystallization, and pointed out the modes of transition from primitive to secondary figures. If we attempt to split a cube of fluor spar with the blade of a knife, assisted by a hammer, it will only yield with facility in the direction of the solid angles; and, pursuing the division in these directions, an octohedron will be the resulting figure.

Haüy obtained six primitive forms, which by further mechanical analysis may be reduced to three integral elements. The secondary forms are supposed to arise from decrements of particles taking place on different portions of the primitive forms. Thus a cube, having a series of decreasing layers of cubic particles upon each of its six faces, will become a dodecahedron if the decrement be upon the edges, but an octohedron if upon the angles; and by irregular, intermediate, and mixed decrements, an infinite variety of secondary forms will ensue, one example of which is given in the first of the accompanying figures.





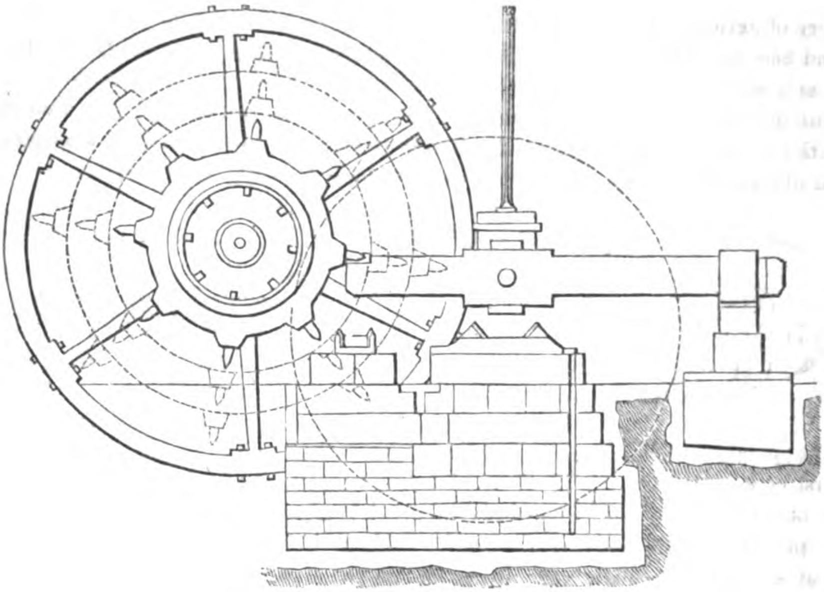
In crystallography we meet with appearances which Haüy's theory but imperfectly explains: a slice of fluor spar, for instance, obtained by making two successive and parallel sections, may be divided into acute rhomboids; but these are not the primitive form of the spar, because, by the removal of a tetrahedron from each extremity of the rhomboid, an octohedron is obtained. Thus, as the whole mass of fluor may be divided into tetrahedra and octohedra, it becomes a question which of these forms is to be called primitive, especially as neither of them can fill space without leaving vacuities, nor can they produce any arrangement sufficiently stable to form the basis of a permanent crystal. To obviate this incongruity, Dr. Wollaston very ingeniously proposed to consider the primitive particles as spheres, which, by mutual attraction, have assumed the arrangement which brings them as near as possible to each other. When a number of similar balls are pressed together in the same plane, they

form equilateral triangles with each other; and if balls so placed were cemented together, and afterwards broken asunder, the straight lines in which they would be disposed to separate would form angles of 60° with each other. A single ball, placed any where on this stratum, would touch three of the lower balls, and the planes touching their surfaces would then include a regular tetrahedron. An example of this simple and beautiful theory is exhibited in the right-hand figure on the previous page.

The working of *metals* is a strictly chemical art. According to Moses, it was known before the deluge. But that dreadful calamity deprived the greater part of mankind of this as well as other arts useful to life. It was not long, however, after this period, till some metals, at least, were known to the eastern nations; for in the days of Abraham they seem to have been common in Egypt, and several countries of Asia. In many parts of the world the precious metals, and especially gold, may be found without the necessity of digging into the bowels of the earth. Torrents pouring down from the mountains deposit great quantities of gold in the beds of brooks and rivers. The ancients speak of several rivers famous for rolling down gold, silver, copper, and even tin, in their waters; and we still know of certain streams which enjoy this advantage. Gold is found in this way not only in grains, but in masses of considerable bulk. In Peru pieces of nearly pure gold have been found, some of which weighed more than an ounce, and in Africa we have instances of natural ingots of a still larger size.

Even when men came afterwards to dig for metals in mines, they would at first find little difficulty in refining them; for on the tops of mines metals are commonly found quite pure, or with very little foreign admixture. At the discovery of the celebrated mine at Potosi, we are told that the vein was so rich that the metal appeared elevated like a rock above ground. According to Acosta, it was a kind of ridge upon the top of a mountain, 300 feet in length, and thirty in breadth. "In the mine of Salcedo," says Ulloa, "they at first found lumps of silver, which gave them no further trouble than to cut them with a chisel; and on the mountain Ucuntaya there was discovered, in the year 1713, a prodigious crust of solid silver, which yielded several millions of dollars." In Hudson's Bay there is a mine of red copper, so rich and pure that without using fire, and only by beating it between two stones, the inhabitants are enabled to form it into all kinds of utensils that they have occasion for. It is reasonable to judge of the ancient mines by these specimens of the metallic treasures of modern countries which are but little frequented; and, when we consider these facts, we shall not be greatly surprised at the abundance of implements of metal in very remote times. Copper is a metal of great tenacity and considerable hardness: so that it furnishes a material not unfit for the fabrication of workmen's tools, and cutting instruments. The swords, hatchets, and daggers, of very ancient nations were of copper, either pure or mixed with tin, by which its hardness is considerably increased. But copper is very inferior as a material for sharp-edged instruments to iron, which may be made by certain processes to cut the hardest substances, and to retain its edge for a long time. Iron, however, is by no means easily disengaged from its ore, and is hardly ever found natural in its metallic state. To convert the ore of iron into metal, it must be pounded and washed, and smelted by intense heat more than once, and in contact with charcoal, or some substance capable of reviving it from the state of dross; and, to form it into steel, still more complicated processes are necessary, and nearly all these manipulations require the labour of the chemist for their first invention. Iron forms the great source of our commercial wealth, and those who have only seen the vast sledge whirled by human arms can have but little notion of the giant powers of the tilt hammer when put in motion by machinery. Hammers weighing many hundred weight carry on their unvaried course as though their ponderous arms possessed the miraculous powers ascribed to Briarius in the olden time. They

are sometimes impelled by water and at other times by steam; but in all cases they are provided with a large fly-wheel to equalise their motion, as in the accompanying engraving.

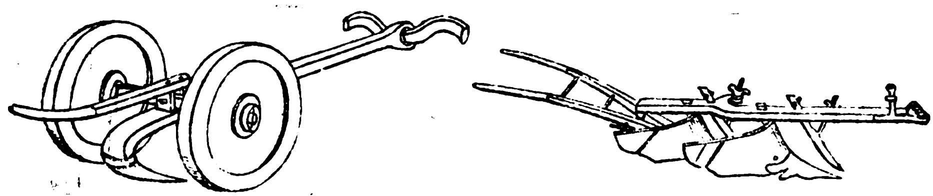


The mass of iron forming a tilt hammer is now supported on a large beam, somewhat similar to a scale-beam, and a strong axis passes through the beam, on which it works as a fulcrum. The projecting pegs are made to depress the one extremity, which of course tends to elevate the opposite end; and the momentum which it acquires in its subsequent descent presses on the iron and moulds it into the required form.

Although all the metals are skilfully worked by English artificers, yet it is most remarkable that those in which they excel are the most refractory; those which, when dug out of the earth, have the smallest importance, but to which thought and labour give the highest utility; those on which the hand of man, directed by his genius, accumulates the greatest factitious value; that is to say, a value which is nearly null in the savage state, but which goes on increasing in the exact ratio of intellectual civilization. The French, on the contrary, have turned their attention to the metals which have the greatest value in themselves, and to which, when wrought, the workmanship adds the smallest merit. Thus jewellery has long been a favourite manufacture with them, as well as the fabrication of the precious metals in all their shapes. These are the most luxurious and the least useful of the metallurgic arts; they are the least intellectual also, as gold and silver are more easily purified and melted than iron. Necessitous nations have, indeed, fabricated jewellery, but not until more urgent wants had been satisfied, and previous exertions had brought home the wealth which in some measure entitles man to indulgence. Some nations, too, whose demand for domestic consumption was small, yet fabricated them for the gratification of others: thus anciently did Tyre and Sidon. Thus Venice and the Netherlands have at different times been celebrated for their gold and silver works, but only when the immediate necessities of those republics had been satisfied, only when other objects more useful had been produced both for the home and the foreign market; and the woollen cloths of Bruges were some centuries earlier than the plate and jewellery of the same city.

Agriculture owes almost all its present improvements to the science of chemistry. It is true that many ingenious mechanical contrivances have been suggested by the mere tiller

of the earth, and by this means the labour of the husbandman considerably abridged. But the real character of the various soils, which must form the basis of all theoretical agriculture, was scarcely at all developed prior to the close of the last century. It is indeed to the discovery of agriculture that we owe a large portion of the arts and sciences. As long as mankind had no other way of subsisting but by hunting, fishing, and feeding their flocks, the useful arts made but little progress; and those nations who do not practice agriculture have still but a very slender acquaintance with the arts and sciences. We cannot better illustrate the past and present states of agriculture than by taking one of the most elementary of agricultural instruments, and comparing its modern with its ancient form.

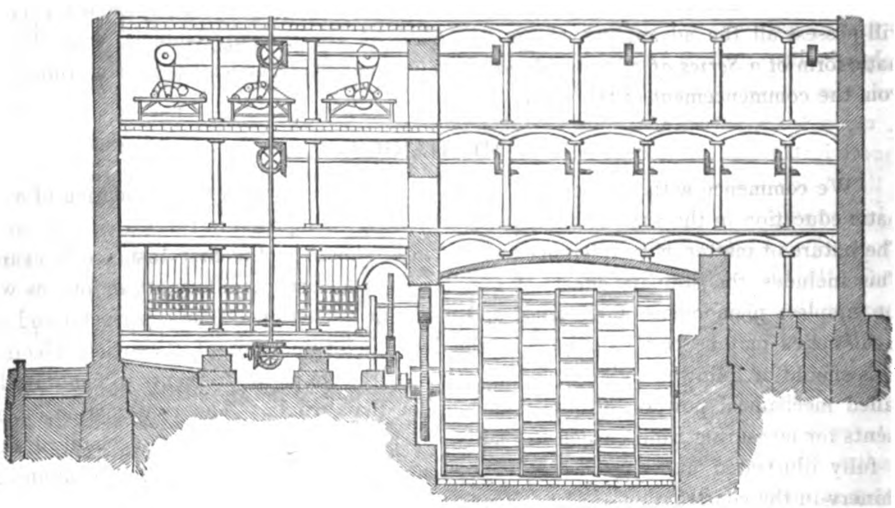


The plough, as it was employed by the Roman agriculturist above 2000 years ago, may first be adverted to. It will be seen by a reference to the above sketch that it consisted merely of a hook, which had no way of clearing itself of the soil through which it was impelled, sometimes by the labour of men and at other times by animal power. It did not, in fact, cut a track through the earth, but tore a groove in the soil. Let us contrast this primeval instrument with lord Somerville's double-furrow plough, and we shall then find that the chemical and mechanical construction of the apparatus is strikingly dissimilar to the one just examined. Chemically speaking, air is essential to the existence of vegetable life: the root serves to attach the plant to the soil, and is one of its organs of nutriment. Now, to enable the root to shoot freely, the earth must in the first instance be broken up and then exposed to the action of the atmosphere. This is most effectually performed by the operation of the improved plough; for instead of the earth being raked or torn up, as in the former case, it is now cut in a series of slices, forming in some cases a single and in others a double furrow. The old mode of ploughing was in fact little more than the preparation of a series of grooves for the seed, and with little chemical advantage to the soil, which was afterwards necessitated to lie fallow for a considerable period of time. Indeed we find that though the presence of light, air, and moisture, aided by a due temperature, are necessary requisites for the growth of plants, yet they also derive considerable nutriment from the soil, which becomes impoverished by their growth, and ultimately incapable of supporting vegetation, unless aided by manures. Now it is to the chemist that we must look for the sort of manures best fitted for this purpose; and the agriculturist who seeks for information upon the subject cannot do better than consult Sir Humphry Davy's *Elements of Agricultural Chemistry*, which has formed the ground-work of all the subsequent treatises.

Our space does not permit of any detailed view of the useful arts, but there is one to which this country is so much indebted, and which owes so much of its excellence to the aids afforded by chemistry, that some notice appears essential. The history of the cotton manufacture alone would form a useful as well as an interesting volume, and it would serve to show from what comparatively insignificant sources first-rate cities, and even large districts, may become wealthy and influential. The art of weaving is of great antiquity, and appears even to have arrived at considerable perfection in the remotest ages. To do this it is not necessary to have recourse to very complicated machinery, as the inhabitants of the east at present weave very fine and beautiful stuffs with comparatively simple instruments. A shuttle, and a few small pieces of wood, are sufficient for their purpose.

It may not be improper to observe that, in ancient times, the work of weaving was performed in a standing posture. This is attested both by Homer and Virgil. The warp was extended perpendicularly from top to bottom, and kept firm by means of a piece of wood, to which heavy weights were appended. The Egyptians, it is said, were the first who changed this incommodious and fatiguing posture into that of sitting at the work as our weavers do at present. It is well known that it was women alone who originally spun, wove, and even dyed wool and cloth. Besides the materials for clothing furnished by the animal tribes, there are a variety of plants, such as cotton, flax, hemp, &c., which supply a substance exceedingly proper for this purpose. It probably would not be long before men began to manufacture cotton, as the seeds of this shrub are lodged in a kind of down, which has a great resemblance to fine wool, and requires but little preparation to render it fit for spinning. We may therefore conclude that cloth of cotton was a very ancient invention.

The early cotton weaver, placed before a loom of the simplest kind, could scarcely interlace more of the fabric he proposed to manufacture than would suffice for the wants of his own family. The water-wheel and steam-engine now, however, afford such admirable substitutes for animal power, that a single manufactory will supply enough cotton for a large city. One of these wholesale producing mills is exhibited in the subjoined engraving.



In this case water is the impelling power; the mountain stream, guided by the hand of human ingenuity, is made to strike against, and cause to revolve, the principal axis of the machine. Its power is then conveyed into a variety of channels, each putting in motion the machinery for one or two individuals. Here, then, the produce of the cotton plant is converted into a durable and beautiful fabric, frequently vieing in tints with those produced by the looms of Tyre in the olden time; whilst those fabrics which are intended to retain a glossy whiteness acquire that character by the agency of a chemical process in a few hours, though the old arrangement of bleaching required weeks, and in some cases months, of toilsome labour. In conclusion, it may be proper to state that the application of chemistry to the useful arts has been one of the primary objects in the following pages, which are intended as far as possible to familiarize science, by stripping it of those technicalities which serve rather to astonish and confound than to instruct the real enquirer after knowledge.

ANALYTICAL TABLE OF CONTENTS.

[The alphabetical form of arrangement necessarily adopted in all cyclopædical works has hitherto prevented their being employed as a means of systematic instruction. To remedy this inconvenience, we have prepared the following analytical table, in which we purpose pointing out, under each head, the most useful mode of studying the branches of science there classed together. It is obvious that by pursuing this plan the British Cyclopædia will possess all the advantages of an *Alphabetical Dictionary,* combined with the systematic form of a *Series of distinct Treatises,* an arrangement which has been a primary object from the commencement of the work.]

MECHANICS.

We commence with this science, as it should evidently form the foundation of a systematic education in the various branches of knowledge comprised in this division of our work. The nature of matter, with reference to *attraction,* should in the first instance be examined. This includes the ordinary effects of gravitation, cohesion, capillary attraction, as well as the simplest phenomena of electrical and magnetic attraction. The centripetal and centrifugal forces may be best examined in the introductory portion of the article Mechanics. This should be followed by an acquaintance with the simple instruments to facilitate labour called mechanical powers, also described under that article. The construction of instruments for measuring time, which in reality consist of a combination of mechanical powers, is fully illustrated under Clock, Watch, and Pendulum. The mode of combining machinery in the construction of Mill-Work should be succeeded by an examination of the theory of Wheel Carriages.

The mechanical properties of the atmosphere form an interesting branch of this subject. They are discussed under the articles Air, Atmosphere, and Pneumatics. The air-pump, which forms an important auxiliary to this branch of science, is illustrated with a plate under Pump. The elasticity of the air is shown under the article Air-Gun.

The phenomena of sound, which are mainly produced by the mechanical vibrations of the air, may now be examined with advantage. The articles Acoustics, Sound, Ear, and Wind-Instruments, contain all that is necessary under this head.

Having thus pointed out the sources by which an acquaintance may be acquired with the mechanical properties of the atmosphere, we may next proceed to apply them in the construction of the Barometer and the Water-Pump.

The nature of the fluidity of water, as well as its pressure, is described under Hydrostatics and Press; and the history of our acquaintance with its compressibility at page xxxv in the Introduction. The theory of Specific Gravities should also be carefully studied, and if possible experimentally illustrated. The motion of water, as well as its mechanical properties, is examined under Water-Wheel, Pumps, and Water-Ram, and its passage

through various sized orifices, under AJUTAGE. AEROSTATION, as a branch of hydrostatics, and the various mechanical contrivances for elevating and depressing balloons, will be found under AERONAUTICS.

The theory and construction of the STEAM-ENGINE may now be understood. Its history is given under that article, and its application to locomotive purposes is also treated of under CARRIAGE and RAIL-ROADS.

Mathematical investigations have been as much as possible avoided in discussing the subjects to which we have thus briefly adverted. The reader should, however, make himself perfectly acquainted with the articles ALGEBRA and GEOMETRY at the commencement of his mechanical studies, as they are essential to a right understanding of many of the articles which occur.

LIGHT, ELECTRICITY, AND MAGNETISM.

The phenomena at present known in connection with these sciences are so analogous as to render it necessary for them to be studied in conjunction. Some of the properties of Light, with reference to its natural effects, are discussed under that article, and should first be examined. The history of Optics, combined with the Introduction, exhibits a complete view of the progress of that science; and the articles Microscope, Micrometer, and Telescope, illustrate the present state of knowledge with reference to the construction of those optical instruments. The theory of the Burning-Glass and Burning-Mirror will be best understood by examining those articles in connection with Refraction and Reflection. The Rainbow and Polarization of Light, which are usually found difficult subjects to comprehend, may now be understood.

Electricity and magnetism are intimately connected with the previous subjects. After consulting the general articles Electricity, Galvanism, and Magnetism, their connection will be further illustrated under Electro-Magnetism, and Spectrum. The best forms of the Compass, and mode of constructing Professor Barlow's improved apparatus, will be found under that article and Magnetism.

ASTRONOMY.

The study of this branch of science may be best commenced with the articles Newtonian Philosophy and Attraction. The history of Astronomy should be followed by an acquaintance with the sizes and relative situations of the planetary bodies, and their satellites taken in detail; the phenomena of eclipses, and the causes of the tides, may also then be readily understood. The Seasons are beautifully illustrated by Mr. Christie's tellu-

rium, described under that article, and a knowledge of practical astronomy may be best acquired by a reference to the various instruments, as they occur in the work.

ANATOMY, MEDICINE, AND CHEMISTRY.

The history of these subjects, as well as physiology, pathology, &c., is given in the Introduction to this work; and our acquaintance with the structure of the human body must evidently be commenced with the articles ANATOMY, PHYSIOLOGY, MUSCLES, and NERVES. The study of the ATOMIC THEORY is an important part of Chemistry, and the student in this science will do well to make himself acquainted with the phenomena of light, heat, and electricity, preparatory to an examination of ponderable matter. OXYGEN, CHLORINE, and IODINE, will next come under his consideration, to be followed by the simple idifiable and inflammable substances. The metals, as well as the bodies which compose

the various animal and vegetable substances, will be found interspersed through the miscellaneous articles of the work.

FINE ARTS.

Painting and sculpture form the principal features of this division. The history of painting will be found under the article ARTS, FINE, and the principal styles of the art are illustrated under the general titles of BYZANTINE, ÆGINETAN, GERMAN, ITALIAN, and NETHERLANDS, STYLES. These should be read preparatory to the study of the technical parts of the subject, which are discussed under DRAWING, GROUPING, PAINTING, PORTRAITURE, and WATER-COLOURS. ENGRAVING forms a middle link between painting and SCULPTURE; the latter is discussed in the general articles SCULPTURE, ARTS, BASSO RELIEVO, GEM ENGRAVING, and DACTYLIOTHECA.

MUSIC holds the next rank in the fine arts. The general article must be consulted in connection with CHORD, CONCORD, CHORUS, NOTE, SINGING, SOLO, SOLFAING, TIME, TONE, and the various minor articles which occur.

HERALDRY is illustrated in that article, and the general terms occur in the miscellaneous articles dispersed through the work.

USEFUL ARTS.

This divison occupies a very wide range. ARCHITECTURE would properly belong to the preceding division; but, as it would separate the theoretical from the practical parts of building, it has been deemed advisable to keep the group of articles connected with architecture under the present head. The other branches of the useful arts require no particular classification, only it may be proper to remark that they are kept as much as possible in a systematic form. Thus the manufacture of hats, of which the base is generally a woollen fabric, is given under WOOLLEN MANUFACTURE, and under ORES we give the general processes for preparing the metals employed in different metallurgical works.

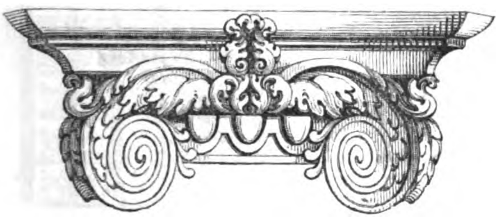
(9)

THE

BRITISH CYCLOPÆDIA.

DIVISION I.—ARTS AND SCIENCES.

Abacus, or **Abaciscus**, in *Architecture*. The Greek derivative of this word signifies a table or tablet, which form the ancient abacus invariably assumed. The accompanying wood-cut will point out the situation of the abacus with reference to the capital of a Grecian column, of which this species of architectural ornament formed the upper part.



The shape of the abacus differs in the various orders. In the remains of ancient Egyptian architecture it is, in some instances, nothing more than a plain cube of stone; and in others, two or more such cubes placed one above the other. Among the Greeks and Romans the abacus is the most essential portion of the capital, though in the original column it was only a tile to protect the upper portion of the shaft. In the Tuscan, the Doric, and the Ionic orders of architecture, the plan of the abacus is rectangular; but in the Corinthian, and Roman, or Composite orders, it is hollowed into circular indentations; and, except in a very few instances, as in those of the capitals of the Poikile at Athens, cut off at the angles. The term abacus is also, but inappropriately, applied to the upper member of any large pedestal.

Abacus is also the name of an ancient instrument for facilitating operations in arithmetic. The working of simple numbers by counters, was obviously well fitted for unfolding the principles of calculation, and it is a curious fact, that in our own times, both Bell and Lancaster have found it advisable to resort to instruments closely resembling those employed in the elementary schools of Greece and Rome. The greater part of the instruments used by the ancients were of a very simple character, and fitted but for the most simple processes; but the apparatus of Napier, Pascal, and Babbage, have given an importance to the subject, which can only be appreciated by those acquainted with the detail of their several assertions. To render this intelligible to our readers, we propose commencing with the earliest form of the abacus, and then tracing its most important improvements, until we arrive at that master-piece of mechanical ingenuity, the machine invented by Mr. Babbage.

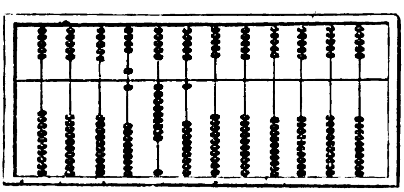
The ancient *abacus* was divided from the right to the left hand, by vertical columns, on which a series of pebbles were placed as counters, to denote units, tens, hundreds, thousands, &c. The labour of counting and arranging those pebbles was afterwards sensibly abridged, by drawing across the board a horizontal line, above which, each single pebble had the power of five. In the progress of luxury, *tali*, or dies made of ivory, were used instead of pebbles, and small silver coins came to supply the place of counters. But the operations with the *abacus* were rendered still more commodious by substituting for such *tali* or counters, small beads strung on parallel threads, and sometimes pegs stuck along grooves. With such an instrument it is not difficult to perceive how the simpler additions and subtractions could be performed with tolerable expedition; but to accomplish a process of multiplication or division, even on the smallest scale, must have been a work of tedious and most irksome labour. Accountants by profession, among the Romans, were styled *calculators* or *rationarii*. Various expedients seem to have been employed for shortening the arithmetical operations. The different positions of the fingers were, for that purpose, used to a certain extent. Boethius treated largely of the subject; and even the venerable Bede, has given very diffuse rules for what was called *digital arithmetic*.

When calculations with counters became more involved, the table on which they were performed, being necessarily of a very considerable size, was called the bench or *bank;* and hence our term for an office where money transactions are negociated. The Court of Exchequer, introduced into England by the Norman Conquest, and intended for auditing the revenue of the crown, had its name from *scaccarium*, which in modern Latin signifies a *chess-board*. The accounts were cast up by the tellers, or *computators*, on a large table covered with black cloth, *chequered* with white lines, on which were placed counters, or small foreign coins, to denote successively pence, shillings, and pounds; proceeding afterwards on the several distinctures of the cloth, by units, tens, hundreds, &c. Sums of money were also rudely marked on *tallies*, so called because they consisted of white sticks of hazel or willow, split up and cut square at both ends; a very fine notch on them denoted a penny, one rather larger a shilling, and one still larger a pound; the notch next in size represented twenty pounds, a larger one expressed a hundred, and the largest of all a thousand. This very strange practice has been handed down to our own times; another striking instance of the blind obstinacy with which

ancient usages, however absurd and ridiculous they may through time have become, are yet retained in public offices, and especially in our courts of law.

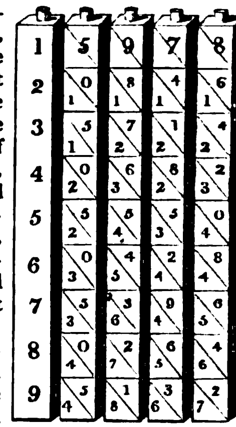
The Chinese have, from the remotest antiquity, used in all their calculations, an instrument which they call *Swan-pwan*, or Swan pan, and which is somewhat similar to the Grecian abacus. There are large and small ones. Those for mercantile purposes consist of many rows of small balls strung on wires, containing fifteen balls on each, with space for their being moved up or down with ease. Those rows of balls are divided by a cross bar of wood, extending from side to side, leaving five balls above and ten below. Each ball of the upper row is of the value of the ten lower balls. By moving one of the upper balls down to the bar, the ten lower balls, which had been moved up to the bar, are at liberty to represent any further sum, till they have all again reached the bar, when another of the upper division is moved down, and so on till the five balls are engaged, when their value is represented by one ball on the adjoining wire, on the left hand, and so on to any amount. For example: the product of the first five balls would give 50, or five tens; and five of the second would give 250, or five fifties; and five of the third would give 1250, or five 250's, and so on to any extent. The person who reckons generally begins about the centre of the board, allowing himself sufficient space towards the left hand. To illustrate the principle by English money, the process is simply thus:—Suppose an article cost £1 7 4 it would be denoted by one ball on one row, seven on the second row, and four on the third; and the second sum to be added 10 1 9. They now begin on the right hand, 9 and 4 being 13, they would move one ball up under the seven balls, and move down three balls from the four, leaving one; by adding one to the eight balls, it would become nine; 10 and 1 making 11, they would move down one from the upper balls, and retain the lower ball, the total would then read £11 9*s.* 1*d.*: as shown in the accompanying cut.

£1	7	4	
10	1	9.	
£11	9	1	



In the divisions of a tale or of a dollar, their highest fraction being nine, and two nines giving 18, the ten being represented by one ball, and the eight differently placed, an error can seldom occur in their mode of addition, or even in subtraction. The swan-pwan is an invariable companion of every counter throughout the whole of China, as it saves the trouble of putting down the prices of a number of articles, and then casting them up, the amount being shown as quick as a person can name them separately.

In performing the ordinary operations of multiplication and division, it is easy to perceive that our object would be much facilitated, if we possessed previously a set of numbers expressing the several products of the multiplicand and each of the nine digits. Such a table might be procured by the simple addition of that multiplicand to itself, the requisite number of times in order to produce its double, triple, quadruple, &c.; but an abridgement of this nature, in the calculation, could only be obtained by an operation much longer than that which it is desired to abridge. The celebrated Napier, the ingenious inventor of logarithms, has, however, contrived an instrument, by means of which this difficulty is removed, and which, by the performance of a very simple mechanical operation, is made at once to present the required product of the multiplicand and any single figure. It is usually known by the name of Napier's Rods or Bones, and is described by the noble inventor in his *Rhabdologia*, published at Edinburgh in 1617.



The accompanying engraving exhibits this instrument, or rather a portion of it, the nature of which may be best imagined by supposing the ordinary multiplication table to be drawn on a plate of metal, ivory, or pasteboard, and conceiving the vertical columns of which it is composed, to be then cut asunder, so as to be rendered moveable. The figures contained in the small squares of that table are, however, differently written on these columns or rods, each of which is divided by a diagonal line into two small triangles, in the one of which is found the unit's digit, and in the other the ten's digit of the number which belongs to that square, the same arrangement being uniformly preserved throughout the whole number of squares. The apparatus will then consist of a number of these rods ranged vertically, each of which is headed by one of the nine digits, beneath which are placed in succession the respective products of that number multiplied by 2, 3, 4, &c., 9. It is obvious that of each of these rods there must be more than one; for as many times as any figure occurs in the multiplicand, so many rods of that species, that is, with that figure at the top of them, must we have. For all ordinary calculations, six of each will be sufficient; and there must also be as many rods of cyphers. To perform the operation of multiplication with this instrument, we must first lay down a rod headed by unity, which may be called the index rod; to the right of this is to be placed another, at the top of which is the figure in the highest place of the multiplicand; adjoining this is to be set a third, headed by the next figure of that number, and so on with each, until as many rods (exclusive of the index) have been laid down as there are digits in the multiplicand. The instrument will then present a table of products of the multiplicand and each of the nine digits; for in the line of squares standing against any figure of the index rod, is the product of the multiplicand and that figure. Therefore, the sum of the products contained in the respective lines of squares which stand opposite to each figure of the index rod, corresponding to the figures of the multiplier, is the result required in an operation of multiplication.

It should be observed, however, that the figures in those squares must be reduced to the ordinary rotation, before they can be so transferred for addition, as

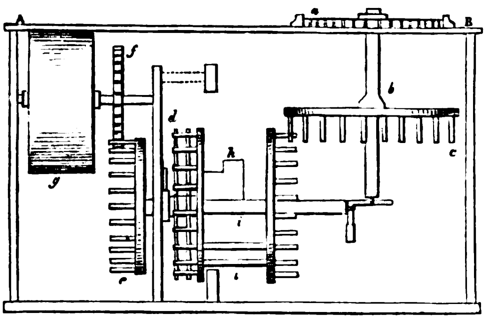
will be seen in the following example:—to multiply 5,978 by 937. Having placed the rods in the proper situation for 5,978, as in the above figure, we must proceed to add together the numbers contained in the line of squares opposite to the figure in the index rod, which corresponds to the first figure of the multiplier, namely, 7. A simple inspection of the illustration will show that the figures contained in the two contiguous triangles of each two squares are of the same denomination, thereby greatly facilitating the addition of the numbers contained in any line of squares. The sum of the products contained in the line opposite 7 is 41,846; the result for the next figure of the multiplier 3, is 17,934 tens; and for 9, 53,802 hundreds; the sum of these three numbers is 5,601,386, the result required. The application of the instrument to the purposes of division will be evident upon a moment's reflection.

One great and obvious defect of an instrument of the above nature is, that its performance is imperfect, inasmuch as the sum of the products contained in any line of squares is not completely arranged; the mental operation of adding together the digits of the same denomination being requisite in order to obtain a result conformable to the ordinary system of notation. To obviate this defect, several machines have been invented by various individuals so constructed as to collect together all the digits of the same denomination, and, as it were, register the excess of any above 9. The great Pascal was the first who succeeded in reducing to pure mechanism the performance of a variety of arithmetical operations, and a description of the instrument by which he effected this object is to be found in the fourth volume of the *Machines Approuveés* of M. Gallon. In 1673, Sir Samuel Morland published an account of two different machines which he had invented, one for the performance of addition and subtraction, and the other for that of multiplication, without however developing their internal construction. About the same period the celebrated Leibnitz, the marquis Poleni, and M. Leupold, directed their attention to the subject, and invented instruments for accomplishing the same purpose by different methods. Leibnitz published his plan in the *Miscellanea Berolensia* of the year 1709, giving, however, only the exterior of the machine; and Poleni communicated an account of his to the same work, but also explained its internal construction. Both of these machines, together with that of Leupold, were subsequently described in the *Theatrum Arithmetico-Geometricum* of the latter, published at Leipsic in 1727. We must not omit to mention the *Abaque Rhabdologique* of M. Perrault, inserted in the first volume of the work, which we have referred to above, the *Machines Approuveés*, by the Paris Academy, which contains also an account of a *Machine Arithmétique* of M. Lespine, and of three distinct ones of M. Hillerin de Boistissandeau. In 1735, professor Gersten, of Giessen, communicated to the Royal Society of London, a very detailed description of an instrument of this nature which he had invented, and the hint of which, he says, "I took from that of M. de Leibnitz, which put me upon thinking how the inward structure might be contrived."

To give our readers an idea of the general construction of these machines, and of the principles on which it proceeded, we will select for explanation that of Pascal, the earliest. Of those which have since been contrived, there are some which have been considered to possess advantages over that in practice; but as the first of its kind, and as one which may have served as a model to many of its successors, it is the object of our preference on the present occasion.

The accompanying illustration exhibits a general view of the instrument with the operator at work on it, who has one hand employed in putting into motion one of the moveable wheels of the apparatus, and the other engaged in connecting the operations of the machine with the figures contained on the paper by his side. It consists of a box covered with a plate of metal, pierced on one side with several square holes, as represented in the figure. On the opposite side of the plate are a number of toothed wheels, each moveable, and turning freely about its own centre. The first to the extreme right has 12 teeth; the second, proceeding from right to left has 20, and all the others have 10. About each of these wheels an outer rim or circle is described on the surface of the plate, which circle is divided into the same number of equal parts as there are teeth in the wheel which it surrounds, and which is moveable, as it were within it. The figures corresponding to each of these points of division are inscribed on all the fixed circles, commencing with 0 at that portion of each which is nearest to the extremity of the side of the box on which they are placed, and proceeding round in the direction of from left to right. Passing over at each of these *zero* points of division, and attached to the surface of the plate, is a small tongue of metal which projects slightly over the enclosed wheel, so as not however to rest on or be in contact with it, but simply for the purpose of arresting the progress of the rod held in the hand of the operator, as seen in the above illustration, when engaged in imparting motion to any one of the wheels. From the number of teeth which we have given to those wheels, it is evident that the one to the extreme right, which contains 12, is intended for what may be termed a pence wheel; the second, which has 20, for a shillings wheel; the third, which has 10, for the units of pounds; the fourth, for tens; the fifth, for hundreds; the sixth, for thousands; the seventh, for tens of thousands; and the eighth, for hundreds of thousands. By enlarging the machine, this number might be increased, and the power of the instrument extended.

We may now proceed to point out the internal arrangement of the machinery. Motion is communicated by the wheel and axis *a b*, which is furnished with a contrite wheel *c*. This actuates the next in the series which is placed in the opposite direction. On the same axis are placed two similar wheels *d e*, the last of which gives motion to the wheel and barrel *f g*. There are two apertures in the upper plate A B, through which the figures on the barrel may be seen, so that the person who moves the wheel *a* may readily register the amount of motion, by observing the figures as they pass these apertures.



In the complete machine there are several of these trains of wheels, and they communicate with each other by a small lever *h*, shewn in the diagram. Now, if we suppose the first of these barrels to have made an entire revolution, the two connecting bars *i i*, will have raised the lever and moved the communicating wheel of the next train one tooth forward in its course. If, for example, it be the barrel which represents shillings, it will by this means indicate a single pound on the divided circle of the next train.

Notwithstanding the skill and contrivance bestowed upon instruments of a nature similar to that we have just described, their power is necessarily but very limited, and they bear no comparison either in ingenuity or magnitude to the grand design conceived, and nearly executed, by Mr. Babbage. Their very highest functions were but to perform the operations of common arithmetic; Mr. Babbage's engine, it is true, can perform these operations, it can also extract the roots of numbers, and approximate to the roots of equations, and even to their impossible roots; but this is not its object. Its function in contradistinction to that of all other contrivances for calculating, is to embody in machinery the method of differences, which has never before been done; and the effects which it is capable of producing, and the works which, in the course of a few years, we expect to see it execute, will place it at an infinite distance from all other efforts of mechanical genius. Great as the power of mechanism is known to be, yet we venture to say, that many of the most intelligent of our readers will scarcely admit it to be possible, that astronomical and navigation tables can be accurately computed by machinery; that the machine can itself correct the errors which it may commit; and that the results, when absolutely free from error, can be printed off without the aid of human hands, or the operation of human intelligence. "All this, however," says Sir David Brewster, in his entertaining *Letters on Natural Magic*, "Mr. Babbage's machine can do; and, as I have had the advantage of seeing it actually calculate, and of studying its construction with Mr. Babbage himself, I am able to make this statement on personal observation." It consists essentially of two parts, a calculating, and a printing part, both of which are necessary to the fulfilment of the inventor's views, for the whole advantage would be lost if the computations made by the machine were copied by human hands and transferred to types by the common process. The greater part of the calculating machinery, of which the drawings alone cover upwards of 400 square feet of surface, is already constructed, and exhibits workmanship of such extraordinary skill and beauty, that nothing approaching to it has hitherto been witnessed. In the printing part, less progress has been made in the actual execution, in consequence of the difficulty of its contrivance, not for transferring the computations from the calculating part to the copper, or other plate destined to receive them, but for giving to the plate itself that number and variety of movements which the forms adopted in printed tables may call for in practice.

The practical object of the calculating engine is to compute and print a great variety and extent of astronomical and navigation tables, which could not otherwise be done without enormous intellectual and manual labour, and which, even if executed by such labour, could not be calculated with the requisite accuracy. Mathematicians, astronomers, and navigators do not require to be informed of the real value of such tables; but it may be proper to state, for the information of others, that *seventeen* large folio volumes of logarithmic tables alone were calculated under the superintendance of M. Prony, at an enormous expense to the French government; and that the British government regarded these tables to be of such national value, that they proposed to the French Board of Longitude, to print an *abridgement* of them at the joint expense of the two nations, and offered to advance £5000 for that purpose. But, besides logarithmic tables, Mr. Babbage's machine will calculate tables of the powers and products of numbers, and all astronomical tables for determining the positions of the sun, moon, and planets; and the same mechanical principles have enabled him to integrate innumerable equations of finite differences, that is, when the equation of differences is given, he can, by setting an engine, produce at the end of a given time, any distant term which may be required, or any succession of terms commencing at a distant point.

On the means of accomplishing this, we need make no apology for quoting Mr. Babbage's own words. "As the possibility of performing arithmetical calculations by machinery may appear to non-mathematical readers too large a postulate, and as it is connected with the subject of the division of labour, I shall here endeavour, in a few lines, to give some slight perception of the manner in which this can be done; and thus to remove a small portion of the veil which covers that apparent mystery. That nearly all tables of numbers which follow any law, however complicated, may be formed, to a greater or less extent, solely by the proper arrangement of the successive addition and subtraction of numbers befitting each table, is a general principle which can be demonstrated to those only who are well acquainted with mathematics; but the mind, even of the reader who is but very slightly acquainted with that science, will readily conceive that it is not impossible, by attending to the following example. Let us consider the subjoined table. This table is the beginning of one in

very extensive use, which has been printed and reprinted very frequently in many countries, and is called a table of square numbers.

Terms of the Table.	A. Table of squares.	B. First Difference.	C. Second Difference.
1	1		
		3	2
2	4		
		5	
3	9		2
		7	
4	16		2
		9	
5	25		2
		11	
6	36		2
		13	
7	49		

Any number in the table, column A, may be obtained by multiplying the number which expresses the distance of that term from the commencement of the table by itself; thus 25 is the fifth term from the beginning of the table, and 5 multiplied by itself, or by 5, is equal to 25. Let us now subtract each term of this table from the next succeeding term, and place the results in another column (B), which may be called first-difference column. If we again subtract each term of this first-difference from the succeeding term, we find the result is always the number 2 (column C); and that the same number will always recur in that column, which may be called the second-difference, will appear to any person who takes the trouble to carry on the table a few terms further. Now, when once this is admitted as a known fact, it is quite clear that, provided the first term (1) of the table, the first term (3) of the first-differences, and the first term (2) of the second or constant difference are originally given, we can continue the table to any extent, merely by simple addition: for the series of first-differences may be formed by repeatedly adding the constant difference 2 to (3) the first number in column B, and we then necessarily have the series of odd numbers, 3, 5, 7, &c.; and again, by successively adding each of these to the first number (1) of the table, we produce the square numbers."

Having thus thrown some light on the theoretical part of the question, Mr. Babbage proceeds to shew that the mechanical execution of such an engine as would produce this series of numbers, is not so far removed from that of ordinary machinery as might be conceived. He imagines three clocks to be placed on a table, side by side, each having only one hand, and a thousand divisions instead of twelve hours marked on the face; and every time a string is pulled, each strikes on a bell the numbers of the divisions to which the hand points. Let it be supposed that two of the clocks, for the sake of distinction called B and C, have some mechanism by which the clock C advances the hand of the clock B one division for each stroke it makes on its own bell; and let the clock B by a similar contrivance advance the hand of the clock A one division for each stroke it makes on its own bell. Having set the hand of the clock A to the division I, that of B to III, and that of C to II, pull the string of clock A, which will strike one; pull that of clock B, which will strike three, and at the same time, in consequence of the mechanism we have referred to above, will advance the hand of A three divisions. Pull the string of C, which will strike two and advance the hand of B two divisions, or to division V. Let this operation be repeated; A will then strike four; B will strike five, and in so doing will advance the hand of A five divisions; and C will again strike two, at the same time advancing the hand of B two divisions. Again pull A, and it will strike nine; B will strike seven, and C two. If now those divisions struck, or pointed at by the clock A be attended to and written down, it will be found that they produce a series of the squares of the natural numbers; and this will be the more evident, if the operation be continued further than we have carried it. Such a series could of course be extended by this mechanism only so far as the three first figures; but this may be sufficient to give some idea of the construction, and was in fact, Mr. Babbage states, the point to which the first model of his calculating engine was directed.

In order to convey some idea of the power of this stupendous machine, we may mention the effects produced by a small trial engine constructed by the inventor, and by which he computed the following table from the formula $x^2 + x + 41$. The figures as they were calculated by the machine, were not exhibited to the eye as in sliding-rules and similar instruments, but were actually presented to it on two opposite sides of the machine, the number 383, for example, appearing in figures before the person employed in copying. The following table was calculated by the engine referred to:

41	131	383	797	1373
43	151	421	853	1447
47	173	461	911	1523
53	197	583	971	1601
61	223	547	1033	1681
71	251	593	1097	1763
83	281	641	1163	1847
97	313	691	1231	1933
113	347	743	1301	2021

While the machine was occupied in calculating this table, a friend of the inventor undertook to write down the numbers as they appeared. In consequence of the copyist writing quickly, he rather more than kept pace with the engine at first, but as soon as five figures appeared, the machine was at least equal in speed to the writer. At another trial, thirty-two numbers of the same table were calculated in the space of two minutes and thirty seconds, and as these contained eighty-two figures, the engine produced thirty-three figures every minute, or more than one figure in every two seconds. On a subsequent occasion, it produced 44 figures per minute; and this rate of computation could be maintained for any length of time.

It may be proper to add, that M.. Babbage stated to the editor of this work, that he considered the powers of his machine as scarcely at all developed—indeed, that the automaton was yet but in its infancy. If such be the childhood of this gigantic engine, what may we not expect from its maturity? There is a general belief that this gentleman has received a large parliamentary grant as a reward for his invention; this is, however, a vulgar error. He has superintended the construction of the instrument at the expense of the Government, but he has not directly or

indirectly received the slightest pecuniary compensation for his services.

Abaissed, *abaissé*, a term used in Heraldry to express the situation of the *fesse*, or any other bearing, when it is depressed below the centre of the shield.

Abas, a weight which is used in Persia for weighing pearls. According to Dr. Kelly's late work on Oriental Metrology, it answers to 3.66 diamond grains English, or 2.25 troy grains = .148 decigramme.

Abassi, or Albaajer, a silver coin current in Persia, equivalent in value to two mamoodis, or four chayés. It took its name from Schah Abbas II., king of Persia, under whom it was struck, and is worth about one shilling of our money.

Abatement, a term used in Heraldry, to denote a mark annexed to the paternal coat, in order to express or point out some ungentlemanlike behaviour or infamy, by which that coat is abated or lowered in dignity. The marks of abatement mentioned by heraldic authors are nine in number; but although anciently heralds, or officers of arms, might have settled these bearings as the proper *tesseræ* or abatement of honour to deter men from the commission of such dishonourable acts, scarcely an instance of any one of them having been actually borne, is given by heraldic writers, and the French discard it altogether as an English fancy.

Abatis, a species of military defence formed of trees cut down and laid with their branches turned towards the enemy, so as to protect troops stationed behind them. They are sometimes placed before redoubts and other works, to render attacks difficult; and along the skirts of a wood, in order to prevent the enemy from getting possession of it. In this case, the trunks serve as a breast-work, behind which the troops are posted, and should therefore be so disposed, that the parts may, if possible, flank one another. In addition to these applications, the abatis may often be of essential service, by retarding the progress of the enemy.

Abb, the yarn of a weaver's warp, whence the wool of which it is made is termed abb-wool.

Abdomen, or lower venter, the anatomical term for the belly. This cavity is that division of the human body which is situated betwixt the thorax and the pelvis. It is bounded above by the arch of the diaphragm, behind, by the spine, on the sides and fore part, by the abdominal muscles; and below, the abdominal viscera are supported by what are termed the alœ ilii and the pubis. It contains the viscera more or less immediately connected with digestion, and the kidneys which secrete the urine.

To give greater accuracy to the description of the seat of the viscera, or perhaps rather more strictly, to connect the knowledge of the internal parts with the exterior of the belly, it has been long customary to mark certain arbitrary divisions on its surface, which are called regions.

The epigastric region is the upper part of the belly, under the point of the sternum, and in the angle made by the meeting of the cartilages of the ribs with the sternum. Upon the sides, under the cartilages of the ribs, are the hypochondriac regions, or the right and left hypochondrium. These three regions compose the upper division of the abdomen, in which are seated the stomach, liver, spleen, pancreas, duodenum, and part of the arch of the colon. The space surrounding the umbilicus between the epigastrium and a line drawn from the crest of one os ilii to the other, is the umbilical region. The hypogastric region is of course the lowest part of the belly, consisting of the angle between the umbilical region, the spines of the ossa ilii, and the pubis. The two lateral spaces between the false ribs and the spine of the os ilii, are the iliac regions, or the loins.

The boundaries of the abdomen are everywhere lined by a thin and elastic membrane called the peritoneum, which also more or less envelopes the contained viscera. The peritoneum may be compared to a flaccid bladder behind, and on the outside of which the intestines and other supposed contents are placed. This membrane is then folded around them, and the two sides of the bladder, after enfolding the intestines, are brought together, forming the mesentery. The peritoneum is therefore contiguous on its internal surfaces, or only separated by a vapour called halitus, which after death condenses into a watery fluid.

The term viscera, though referring more particularly to the fleshy or solid contents of the great cavities, is applied generally to all the parts contained in them. The economy of the abdominal viscera is very important in the processes of digestion. The organs destined to receive the food, and to perform the first of those changes upon it, which after a due succession of actions fit it for becoming a component part of the living body—are the stomach and intestines, which may be considered as primary, and the glandular viscera, the liver, the pancreas, and in all probability the spleen, as subservient or secondary organs. These may be divided into the membranous or floating viscera, comprising the whole track of the intestinal canal, and the glandular viscera; or, what is still better, they may be distinguished into those parts which have action and motion, and those which are quiescent, or possessed of no power of contraction. Thus the stomach, intestines, gall-bladder, and bladder of urine (though this belongs to the pelvis), have muscular coats, and possess the power of contracting their cavities; while the liver, spleen, pancreas, and kidneys have no muscularity but in their vessels and excretory ducts.

The intestinal canal may be divided into three parts; the stomach, the great and the small intestines. The small intestines are subdivided into the duodenum, jejunum, and ileon; the great, into the cœcum, colon, and rectum. The stomach, into which the food is conveyed by the œsophagus, or gullet, is the seat of the digestive process; in the duodenum, the food receives the addition of the secretions from the liver and pancreas, and is still further adapted to animalization; in the long tract of the jejunum and ileon the nutritious part is absorbed; and in the great intestines the effete matters are carried slowly forward, and at the same time suffer a further absorption of their fluid contents, until as fœces they lodge in the rectum, or last division of the canal. From this view, it is apparent that each of the divisions of the intestinal canal is marked by some peculiarity in its use or function; and for a more detailed account of their structure individually, we must refer to the several portions of which it is composed.

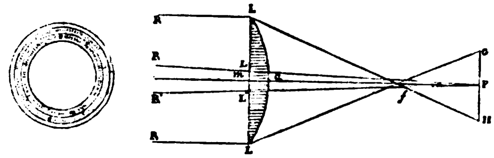
Abductor, a term applied to those muscles which draw backwards the moveable parts into which they are inserted, and of which there are many in the human body.

Aberration of light. We see an object because

the rays of light proceeding from it strike our eyes, and we see the place of the object in the direction in which they proceed. Let us now imagine the earth, in its circuit round the sun, just arrived opposite to a fixed star, which sends off rays perpendicularly to the direction of the earth's motion. The eye of the spectator meets the ray, and as he perceives not his own motion, he supposes the light to be moving in an opposite direction; as, when we sail in a boat, the trees on the shore appear to pass along by us. Thus the eye misses the perpendicular ray, but meets an oblique one, and thence receives the impression of the light in the direction which results from this compound motion, namely, in the diagonal of a parallelogram, the sides of which represent the real motion of the light, and the apparent one (i. e. the motion of the earth), which take place at the same time. The spectator sees the star in its true place only when he is either approaching it, or receding from it, in a straight line. When moving in any other direction, the star appears a little in advance of its true position in the same direction (the maximum is 20″—25″); and we call by the name of *aberration of light* these apparent changes in the situation of the heavenly bodies, occasioned by the motion of the earth. We easily see that these changes are common to all the heavenly bodies, and are only more striking in the case of the fixed stars. They afford an additional proof of the motion of the earth. In consequence of this abberration, the fixed stars appear, during the revolution of the earth about the sun, according as they are situated, either in the plane of the ecliptic, or in its poles, or somewhere between them, in the first case to deviate in a straight line to the right or left of their true place, in the second to describe a circle, in the third an ellipse about that point, which further observation determines to be their real situation. This discovery we owe to Bradley.

The spherical *aberration of lenses* must be understood before the student can at all comprehend the principles of optics. It is generally supposed that the rays refracted from lenses or magnifying glasses meet exactly in a focus; but this is by no means strictly true, as those which pass through the centre or axis of the lense go beyond those which are incident at a greater distance.

In order to understand the cause of spherical aberration, let LL be a plano-convex lens, one of whose surfaces is spherical, and let its plane surface, L *m* L, be turned towards parallel rays R L, R L. Let R′ L′, R′ L′, be rays very near the axis A F of the lens, and let F be their focus after refraction. Let R L, R L be parallel rays incident at the very margin of the lens, and it will be found by the method of projection, that the corresponding refracted rays L *f*, L *f* will meet at a point much nearer the lens than F. In like manner intermediate rays between R L and R′ L′ will have the foci intermediate between *f* and F. Continue the rays L *f*, L *f*, till they meet at G and H, a plane passing through F. The distance *f* F is called the *longitudinal spherical aberration*, and G H the *literal spherical aberration of the lens*. In a plano-convex lens placed like that in the figure, the longitudinal spherical aberration *f* F is no less than 4½ times *m a*, the thickness of the lens. It is obvious that such a lens cannot form a distinct picture of any object in its focus F. If it is exposed to the sun, the central part of the lens L′ *m* L′, whose focus is at F, will form a pretty bright image of the sun at F; but as the rays of the sun, which pass through the outer part of L L of the lens, have their foci at points between *f* and F, the rays will, after arriving at those points, pass on to the plane G H, and occupy a circle whose diameter is G H; hence the image of the sun in the focus F will be a bright disc, surrounded and rendered indistinct by a broad halo of light, growing fainter and fainter from F to G and H. In like manner, every object seen through such a lens, and every image formed by it, will be rendered confused and indistinct by spherical aberration.



The form assumed by the sun's disc is shown by the radial circles at the opposite extremity of the wood-cut.

These results may be illustrated experimentally by taking a ring of black paper and covering up the outer parts of the face L L of the lens. This will diminish the halo G H, and the indistinctness of the image; and if we cover up all the lens excepting a small part in the centre, the image will become perfectly distinct, though less bright, than before, and the focus will be at F. If, on the contrary, we cover up all the central part, and leave only a narrow ring at the circumference of the lens, we shall have a very distinct image of the sun formed about *f*.

For the aberration of light, see the elementary works on astronomy, the dictionaries of natural philosophy by Gehler, Fischer, &c. There is a very good account of it in Biot's *Traité Elémentaire d'Astronomie Physique*, Paris, 1811, 2d Treatise, vol. 3, page 120, et seq. Tables of aberration, accompanied with explanations, are to be found in the baron von Zach's works, *Tabulæ speciales Aberrationis et Nutationis, etc.*, Gotha, 1806, and in the same author's *Nouvelles Tables d'Abérration et de Nutation pour* 1404 *Etoiles, avec une Table générale d'Aberration pour les Planètes et les Comètes*, Marseilles, 1812, and *Supplément*, 1813.

Abluents, medicines applied to wash off from the external or internal surfaces of the body any matters adhering improperly to them.

Abomasum, the fourth stomach of ruminating animals, or that in which the process of digestion is completed.

Abscess, a term applied in Surgery to a cavity containing pus or a collection of puriform matter.

Abscissa. See *Conic Sections*.

Absorbent System, the organs which are employed in the performance of the process of absorption, or that by which the substances that serve for the growth and support of the body are carried into the blood and are assimilated to that fluid. It appears to be a general principle in the animal economy, that all the particles of which the body is composed, after a certain period, lose the power of performing their appropriate functions; and that it consequently becomes necessary to have them replaced by new matter. It is by means of absorption that this exchange of particles take place, the former constituents being taken up by the vessels and returned into the general circulation, to be either discharged, or em-

ployed under some new form, while a different set of absorbents receive the recent matter from the products of digestion, and likewise convey it to the blood, whence it is distributed to all parts of the body. The apparatus by which this process is effected, or the absorbent system, may be regarded as consisting of four parts, the lacteals, the lymphatics, the conglobate glands, and the thoracic duct. It is to Aselli that we are indebted for our acquaintance with the lacteals as a specific and distinct system, possessing a peculiar structure and an appropriate office—a discovery which he made in the year 1622. In the course of his dissections, he observed a series of vessels, unconnected with the arteries and veins, dispersed over the mesentery of a dog; and in consequence of the chyle with which they were filled, he gave them the name of lacteals. After they have acquired a sufficient degree of magnitude, these vessels may be easily recognized along the mesentery; like the venous part of the sanguiferous system, the small branches run together to four larger ones, while these again unite, until the whole compose a few great trunks which terminate in the lower end of the thoracic duct. They are furnished with numerous valves of a semi-lunar form, disposed in pairs, and so as to prevent the retrograde motion of the contents of the vessels. The small branches frequently anastomose with each other, more so, indeed, than either the veins or the arteries; for it is a general law of nature, that the smaller the vessels of every kind, the more freely they communicate and unite with each other. The lacteals are further characterized by the thinness and transparency of their coats, by which they are rendered very difficult of detection, except when they are distended with the white and opaque chyle.

The discovery of the lymphatics was a few years posterior to that of the lacteals; for although their structure and composition are nearly similar, yet, in consequence of their contents being transparent and colourless, they are less easily detected. Like those vessels, they are composed of a fine and transparent, but firm and elastic substance, are provided with numerous valves, and form frequent anastomoses. But though analogous to the lacteals in their principal function and in their ultimate destination, they differ from them in their situation and in their contents; for while those vessels are confined to the mesentery, and serve only to convey the chyle, the lymphatics are found in almost every part of the body, and are filled with a transparent and colourless fluid, which, as its name imports, was supposed to consist principally of water. Their larger channels are arranged into two principal series or systems, one near the surface, and the other more deeply seated. These main branches, for the most part follow the course of the great veins, and are finally reduced to three or four great trunks, terminating in the thoracic duct. This, as we have before observed, receives also the tributary stream of the anastomosing lacteals, and pours the whole of the complicated fluid steadily and slowly, by means of a valve placed for this purpose at its opening, into the left subclavian vein, whence it is conveyed to the heart.

The conglobate, or lymphatic glands, compose a conspicuous portion of the absorbent system. They are met with in different parts of the body, always connected with the lymphatics. They are of various sizes, sometimes simple, sometimes in clusters; and although their use is not understood, we may presume that they fulfil some important purpose from the circumstance of every absorbent vessel during its course passing through one or more of these glands. Although we are not acquainted with the nature of the function which is exercised by these glands, we may fairly presume that they tend in some way or other to the completion or the perfection of the absorbent system, as they are found principally in the higher orders of animals. In those of an inferior description, we have the vessels without the glands, while in those of a still lower order, neither the vessels nor the glands can be detected, so that the process of absorption must be carried on by some more simple apparatus. Respecting the structure of these glands there exists a controversy, whether they contain cells, or whether they consist of a mere congeries of vessels; the earlier anatomists maintaining the former, while the more recent authors adhere to the latter opinion.

The office of the absorbents is literally expressed by their name; it consists in receiving or taking up certain substances, and in transporting them from one part of the body to another. The substances which are thus taken up may be referred to two only, the chyle and the lymph, the former being received by the lacteals, and the latter by the lymphatics. The immediate object of the action of the two sets of vessels is also essentially different, that of the first being to convey a fluid from the part where it is formed, into the blood, in order that it may directly conduce to the nutrition of the body, the latter serving to remove what is useless and noxious, and to dispose of it in such a manner that it may either be applied to some secondary purpose of utility, or be finally discharged from the system. Although there is some uncertainty respecting the anatomical structure of the mouths of the lacteals, and considerable difficulty in explaining the mode in which the chyle enters them, we can have no doubt that they are so dispersed over the surface of the intestines, as to be able to receive the chyle when it is presented to them. By their contractile power, assisted by the mechanical action of the valves, and probably by other causes, the fluid, when it has once entered the vessels, is necessarily propelled from their extremities towards their trunks, until at length it arrives at the thoracic duct. The action and functions of the lymphatics do not appear to be essentially different from those of the lacteals; but there is one circumstance in which these two sets of vessels seem to differ, that while the latter appear to be capable of receiving nothing but chyle, which they are in some way or other enabled to select from the heterogeneous mass of matter through which it is diffused, the lymphatics, on the contrary, possess the distinguishing property of taking up, as occasion may require, every substance that enters into the composition of the body, as well as extraneous matters of various kinds that are accidently or intentionally placed in contact with their mouths. With respect to the thoracic duct we have no reason to suppose that there is any thing specific in its action, or that, except in size, it differs from the other absorbent vessels. Its particular office appears to be that of serving as a reservoir in which the chyle may be deposited for the purpose of being gradually transmitted into the sanguiferous system, as there is some reason to suspect that injury would ensue if too large

a quantity of this fluid were poured into the veins at any one time.

From the above remarks it appears that we are in little doubt respecting the use of the vascular part of the absorbent system; but this is not the case with its glandular appendages. It can scarcely indeed appear surprising that we are unable to explain their use, while their structure is still involved in so much obscurity, and yet, on the other hand, it may be said that we know so little of glandular action, or of the change which it produces upon the fluids that are subjected to it, that we should rather attempt to elucidate the subject by physiological than by anatomical investigations. The most probable opinions that have been entertained upon the point are, either that these glands are proper secreting organs, and are intended to prepare a peculiar substance, which is mixed with the chyle and lymph, or that they offer a mechanical obstruction to the progress of these bodies, by which means their elements are allowed to act upon each other, and thus to produce some necessary change in the nature of the fluids which pass through them.

From the period of the complete discovery of the lacteals and lymphatics, it has been a general opinion both with anatomists and physiologists, that their appropriate office was absorption; but it has been a very warmly contested point whether this operation was exclusively performed by those organs. The ancients supposed the process of absorption as well as that of secretion, to be effected, not by a distinct set of vessels expressly formed for that purpose, but by the peculiar construction of the arteries, or of the veins, or of both. This hypothesis of the absorption of veins without the interference of lymphatics, has been revived within the last twenty years by M. Majendie and M. Flandrin, of Paris; by these gentlemen experiments have been adduced which bear the marks of great ingenuity in their contrivance, and accuracy in their execution, and the results of which are, perhaps, at least as decisive in favour of venous absorption as had been those of Hewson, the Hunters, and Monro, in support of the opposite doctrine. The positions attempted to be established by M. Majendie are first, that it is certain that the chyliferous vessels (lacteals) absorb chyle; secondly, that it is doubtful whether they absorb any thing else; and, thirdly, that it is not proved that the lymphatic vessels possess the power of absorption; and it is proved that the veins have this power. However little we may feel disposed to assent to this doctrine of absorption merely upon the faith of experiments, at least until they have been further repeated and diversified, we may, in the mean time, go so far as to assert that venous absorption is neither impossible, nor perhaps improbable; and that with the evidence which we now have in its favour, we can admit of no physiological hypothesis, or train of reasoning which necessarily involves its non-existence.

We have before observed, that the only substance which the lacteals appear destined to receive, is the chyle, which is conveyed by them from the intestines, where it is produced, to the thoracic duct; but we have reason to suppose that the contents of the lymphatics are of a more miscellaneous nature. How far they may serve for the purposes of nutrition, it is not, perhaps, very easy to ascertain; but we may venture to assert that nutrition is not their sole, or even their primary, function, that being rather the appropriate office of the chyle. We are indebted to John Hunter for the first consistent hypothesis upon this subject; he conceived that the primary use of the lymphatics was to form and fashion the body so as to give it its proper shape, and to enable it to increase in bulk, while its individual parts retained their appropriate figure and proportionate size. Thus we observe the bone of a young animal to possess a characteristic shape, to have a certain number of projections and depressions in the different parts. If we examine the same bone in the adult animal, we shall find a general correspondence between the parts of both; we have, for the most part, the same number of projections, and bearing the same relation to each other. But it is obvious that this change of shape could not have been effected by the accretion of new matter to the original bone, nor by the distention of the parts already existing; in short, the only way in which it could have been accomplished, is by the removal of the particles of which the young bone was formed, and the gradual deposition of others in their proper situations. An operation of this kind can be effected by no means with which we are acquainted, except absorption; thence we conclude, that the lymphatics alone, or at least in conjunction with the veins, are the agents employed for this purpose. The action of the absorbents is still more strikingly displayed in many morbid states of the system where the effects are more visible to the eye, in the occurrence, in an unnatural situation of an effusion of a fluid or a deposition of a solid, in which cases these extraneous substances are gradually removed.

The mode in which the absorbents act is a point of great uncertainty; with respect to the lacteals, they are said to be furnished with a peculiar apparatus attached to their mouths, called villi, consisting of a number of small vessels that are so disposed as to be brought into direct contact with the fluid intended to enter them, as is supposed, upon the principle of capillary attraction, or of an elective attraction between the mouths of the vessels and the chyle. The lymphatics are capable of absorbing a variety of substances differing most widely in their nature, and a peculiar difficulty attends this part of the subject, arising from the circumstance of the densest solids, being so acted upon, as well as the more fluid components of the body. If solution of the substances be necessary, we are at a loss for a proper solvent; and, on the other hand, it is not easy to conceive how they can else be absorbed. This difficulty is partly explained by some physiologists, who bring forward the operation of the vital principle, and say that as long as a part possesses that principle, it is enabled to resist the action of the absorbents, but that it immediately becomes subject to their influence, when it loses that agent. That part of the process which is the most difficult to comprehend, is not, however, developed,—the nature of the change which converts the materials into that state which adapts them for being taken up by the absorbents.

M. Majendie has originated a new hypothesis respecting the mode in which the organs act; he conceives it to be that of capillary action exercised by the sides of the vessels upon the substances to which they are exposed. It is evident, however, that nothing can enter the vessels by this kind of filtration, except what is perfectly dissolved in the fluids, and he does not inform us how this solution is effected. The

conclusions of this distinguished physiologist have been more lately enforced by a series of elaborate and ingenious experiments, excuted by M. Fodera, from which he deduces the following conclusions: 1. That exhalation and absorption may be referred to transudation and imbibition through the pores of the membranous textures, "capillarité des tissus," which enter into the composition of the organs. 2. That this double effect may be produced in all parts of the body, and that the fluids which are imbibed may be conveyed equally by the lymphatics, or by the arteries and veins. The nature of the experiments, however, implying as they do so great a degree of correctness in the execution, ought to render us extremely cautious in receiving them as conclusive of the results which are attempted to be established from them.

A series of experiments have been performed by Dr. Barry, from which he infers, that absorption depends altogether upon atmospherical pressure. A dose of poison, under ordinary circumstances proving fatal in a few seconds, being introduced into a wound, was rendered completely harmless by the application of an exhausted cupping glass over it; and even when the symptoms had commenced, still the vacuum had the effect of speedily and entirely removing them. We may observe, however, that the poison was not simply laid on the surface, but was inserted into a wound; hence it would be immediately mixed with the blood, and carried by the veins to the central parts of the system.

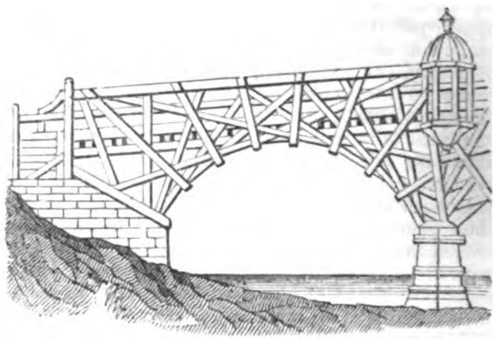
Besides this absorption of substances applied to the skin, and forced into the mouths of the vessels by friction, or other mechanical means, it is supposed, that when the body is immersed in water, the cuticle still remaining entire, the same kind of absorption takes place, and even that the skin has the power of imbibing water from the atmosphere if it exist there in unusual quantity. M. Majendie thinks that the cuticle does not possess this power while in a sound state, either by veins or lymphatics, but that if absaided or strongly urged by the pressure of minute substances that enter into its perspirable pores, the mouths of its minute veins are thus rendered absorbent. The experiments of Dr. Edwards, however, seem conclusive on this point, and would lead us to infer that the function of absorption is actually carried on to a considerable extent, and probably without interruption, although, in differerent degrees, according to the condition of the animal, and the circumstances to which the body is exposed.

Abutment. This architectural term, though very general in its signification, is usually understood to apply but to the extremities of an arch or bridge. Butments of arches are the same with buttresses, and they answer to what the Romans called *sublices*.

One of the most beautiful applications of the abutment will be found in the curved support of the early ecclesiastical and other edifices.

Any person accustomed to the heavy masses of stone and brick work usually employed to resist the lateral pressure in modern edifices, must at once see the advantages of the *flying buttress*, or abutment. About one-third of the materials used in this form possesses a greater degree of strength than could be obtained if the mass had been solid; and then on the score of picturesque effect, the early architect had decidedly the advantage.

The abutments of a bridge, when formed artificially, usually consist of solid masses of masonry, formed by the aid of coffer-dams, or water-tight boxes, in which the abutment is erected; though there are cases in which the abutment is formed naturally.



In the above wood-cut, representing a portion of the wooden bridge erected over the Thames at Walton, by Mr. Ethridge, we have the gravelly soil of the river acting in unison with courses of masonry which form the abutment. The pier in the river acts by forming a direct support, while the abutment combines the perpendicular pressure with the lateral thrust. It will be obvious that the chain bridge, constructed on suspension principles, forms an exception to this view of the abutment; as in the latter case the chains are attached, but have not the same species of pressure.

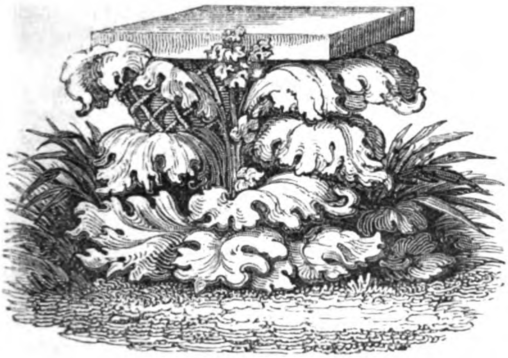
Abyss, in *Heraldry*, the centre of an escutcheon.

Acæna, a Grecian land measure of ten feet.

Acanthus, in *Architecture*, an ornament representing the leaves of the herb bear's breech, which are large and shaggy. It was at first used by the ancients as an ornament to friezes and cornices, and at length to the other members of architecture, but is principally employed as the grand ornament of the *Corinthian and Composite capitals* (See those articles). The Greeks used, for this purpose, the leaves of the cultivated acanthus *(acanthus mollis)*, commonly called brank ursine, or bear's breech, from its shagginess, which grew spontaneously both in Greece and Italy. The Gothic architects and sculptors, on the contrary, have used the wild and prickly acanthus *(acanthus spinosa)*, being smaller in its parts, and more suited to the littleness of their styles of art. Although architecture has made the greatest use of the acanthus, yet the other arts have also adopted it as a chaste and splendid decoration. We find among the ancients, as well as among the moderns, various instruments, household furniture, and utensils, ornamented with leaves of the acanthus. These artists, in preserving the general form and character of the plant, have made their sinuosities and curves more or less prominent to suit their purposes, and have thus given them a more sculpturesque effect. In the Corinthian capital they are executed with more fidelity and elegance; the whole plant surrounds with its aspiring leaves the vase or bell of the capital, as if attempting to lift up the abacus that covers the whole, they then turn down and form themselves into graceful volutes.

The wood-cut on the next page represents the leaves of the plant gracefully bending in the form already described, and the artist has given all that beauty of form which, under accidental circumstances, is said

to have operated on Callimachus in originating the Corinthian capital.



Acatharsia, an impurity of the blood.

Acceleration. See *Motion*.

Accent, a term used in *Music* to denote a certain enforcement of particular sounds, whether by the voice or by instruments. It is generally used at the beginning of bars.

Accident, in *Heraldry*, is an additional note or mark in a coat of arms, not necessarily belonging to it, but capable of being either omitted or retained, without altering the essence of the armour; such as abatement, difference, and tincture. Although often mentioned by heraldic writers, accidents seem to have no particular meaning in blazonry, generally applying to strictures and marks of difference in coat armour.

Accidental, in *Philosophy*, is a term applied to that effect which results from a cause occurring by accident, without apparently following any general laws. Accidental colours are those which seem to depend on the affections of the eye in contradistinction to such as belong to light itself. If we look intensely with one eye upon any coloured spot, such as a wafer placed on a sheet of paper, and immediately afterwards turn the same eye to another part of the paper, we shall see a similar spot, but of a different colour. Thus, if the wafer be red, the seeming spot will be green; if black, it will be changed into white; and in the same manner every colour has a corresponding one into which it is transformed.

Accolé, a French heraldic term which English heralds express by *gorged*, and *collared*. The same word is likewise used by the French to denote two batons, swords, &c. placed behind a shield.

Accompaniment, in *Music* (French, *accompagnement*; Italian, *accompagnamento*), is that part of music which serves for the support of the principal melody (solo or obligato part). This can be executed either by many instruments, by a few, or even by a single one. We have, therefore, pieces of music with an accompaniment for several, or only for a single instrument. The principles on which the effect of the accompaniment rests are so little settled, that its composition is perhaps more difficult than even that of the melody, or principal part. Frequently, the same musical thought, according to the character of the accompaniment, produces a good or bad effect, without our being able to give a satisfactory reason for the difference. Hitherto, the Italians have been most distinguished for expressive accompaniments contained in a few notes, but productive of great effect. In this respect, the Italian music generally surpasses the German and French, as it never weakens the effect of the principal part by means of the accompaniment. The French are far behind both the other nations, in respect to this part of composition, as they frequently estimate the effect by the quantity of notes. The accompaniment requires of the performer the most scrupulous study, and of the composer the greatest care and delicacy. The accompaniment of various solo instruments, as the violin, flute, piano, &c. is extremely difficult, and to give it full effect requires great knowledge and skill. The Italian composers accordingly consider a piano accompaniment for a full orchestra, especially in the recitativo, as a great problem, which they have laboured zealously to solve. As the object of every musical accompaniment is to give effect to the principal part, the accompanier should always aim to support, and by no means to overpower and oppress it. Of all composers, Mozart, even in respect to the accompaniments, claims the first place for the simplicity and beauty with which he amalgamates the leading and accompanying parts, through his unrivalled knowledge and excellent management of the parts for every individual instrument.

Accord, in *Painting*, denotes the harmony that reigns among the lights and shades of a picture.

Accord, in *Music*, see *Concord*.

Accordion. A new musical instrument under this title has lately been imported from Germany, and many of them since constructed in this country. They consist of a double series of vibrating tongues, put in motion by a current of air from a pair of moveable bellows, and when well made, they produce an effect but little inferior to an organ.

Accroché, a term used by French heralds to express one heraldic charge, or bearing, hooked into another.

Acetabulum, in ancient *Metrology*, a Roman measure equal to about one-eighth of our pint, and applicable to both liquid and dry substances. According to Du Pinet, it varied, being for oil, two ounces and two scruples; for wine, two ounces, two drachms, and 1½ grains; and for honey, three ounces, three drachms, one scruple, and two siliquæ.

Acetabulum, in *Anatomy*, is a large spherical cavity in a bone, which receives the convex head of another, thereby forming that species of articulation technically termed enarthrosis. This word is also sometimes used synonimously with cotyledon, to signify a sort of glandular substance found in the placenta of some animals.

Acetic Acid. See *Acid*.

Acetous, an epithet applied to such substances as are sour, or partake of the nature of vinegar.

Acherset, an ancient measure of corn, supposed to be the same with our quarter.

Achiotte, or Achiote, a foreign drug, used in dyeing and in the preparation of chocolate. It is the same with the substance more usually known by the name of *Arnotto*, which see.

Achromatic, or colourless. This word was first introduced by M. La Lande in his work on Astronomy. It is now used to describe those compound optical instruments which transmit light without reducing it into its original elements. The subject will be fully treated of under Optics.

Achteling, a measure for liquids, used in Germany. Thirty-two achtelings make a heemer; four sciltims make an achteling.

ACIDS, in *Chemistry*, a class of substances which are more or less distinguishable by the following properties:—1. When applied to the tongue, they excite that sensation which is called *acid* or *sour*.—2. They change the blue colours of vegetables to a red. The vegetable blues usually employed as a test for this purpose are tincture of litmus and infusion of the red cabbage. If these colours have previously been converted to a green by alkalies, the acids restore them.—3. They readily unite with water.—4. They combine with all the alkalies, and most of the metallic oxides and earths, and form with them various chemical compounds. It may be proper to add, that every acid does not possess all these properties, but as a body, they have those general distinctive characters.

To enable our readers to acquire a clear, and yet perspicuous view of this important class of chemical bodies, it may be adviseable, in the first instance, to briefly enumerate them, and then point out the process used in the manufacture of those chiefly employed in the useful arts. Those of our readers who are disposed to extend their inquiries into the chemical combinations of the acids with other bodies, may do so by referring to the alphabetical arrangement of the work under the several heads of each article. The acids may be thus enumerated:—

Acetic	Hydro-cyanic	Phosphorous
Arsenic	Hydro-fluoric	Prussic
Arsenious	Hydro-sulphuric	Pyro-tartarous
Benzoic	Hypo-phosphorous	Saccholactic
Boletic		Selenic
Boracic	Kinic	Sorbic
Camphoric	Laccic	Stabic
Carbonic	Lactic	Stibious
Cetic	Lampic	Suberic
Chloriodic	Malic	Succinic
Chloro-carbonic	Margaretic	Of Sugar
Chloro-cyanic	Millitic	Sulpho-cyanic
Chromic	Moroxylic	Sulphuretted-chyazic
Citric	Muriatic	
Columbic	Oleic	Sulphuric
Dephlogisticated-muriatic	Oxalic	Sulphurous
	Oxychlolic	Tartaric
Fluo-silicic	Oxymuriatic	Tungstic
Fluoric	Oxyodic	Avric
Formic	Perchloric	Zumic
Gallic	Phosphoric	

We may commence with *sulphuric acid*, being the one most used for chemical and manufacturing purposes.

When sulphur is burned in dry oxygen gas, or vital air, there is no increase in volume; but at common temperatures, a colourless transparent gas is formed, which is distinguished from all other elastic fluids, by a suffocating pungent odour, well known as the smell of burning brimstone. It may be obtained by the action of sulphuric acid upon mercury, in a state of great purity. The mixture may be put into a retort and heated, but the gas must be received over mercury.

It is called sulphurous acid gas.

It extinguishes all burning bodies, when immersed in it, and cannot itself be burned. It is instantly fatal to animal life. When compressed, it assumes the liquid form; or at the degree of cold produced by a mixture of snow, or pounded ice, and salt.

It first reddens blue vegetable colours, and then destroys them; and its bleaching powers are very considerable. The vapours of burning sulphur are much used in whitening silk and straw-work.

One hundred cubic inches of sulphurous acid weigh 67.5: which is exactly double the weight of an equal quantity of oxygen; so that the weights of sulphur and oxygen, in the compound, are equal.

Water at 60° dissolves about 33 times its bulk of sulphurous acid; and the solution possesses its peculiar odour and taste, which is astringent. It cannot, however, be preserved any length of time without change.

A mixture of sulphurous acid and oxygen gas may be kept for any length of time without showing any further disposition to combine, provided they are quite dry. If water be present, the sulphurous acid will gradually unite, with a further proportion of oxygen, and the compound, which is sulphuric acid, will be taken up by the water.

Sulphuric acid is an article of great importance, and is largely consumed in many manufactures; and there are several ways of procuring it for commerce.

By distilling, at a high heat, the salt called green vitriol (which, it will be hereafter seen, is a compound of sulphuric acid and protoxide of iron), a dense, oily, colourless liquid may be obtained; which emits white vapours on exposure to the air. If this liquid be again distilled, at a lower temperature into a receiver surrounded with pounded ice or snow, a transparent, colourless vapour will pass over, which will condense into a white crystalline solid. It is tough and elastic; liquefies at a temperature of 66°, and boils at about 110° or 120°. It has a strong affinity for water, and immediately takes it from the atmosphere. This solid body, there is reason to suppose, is pure *anhydrous* sulphuric acid; but there are some doubts respecting its nature.

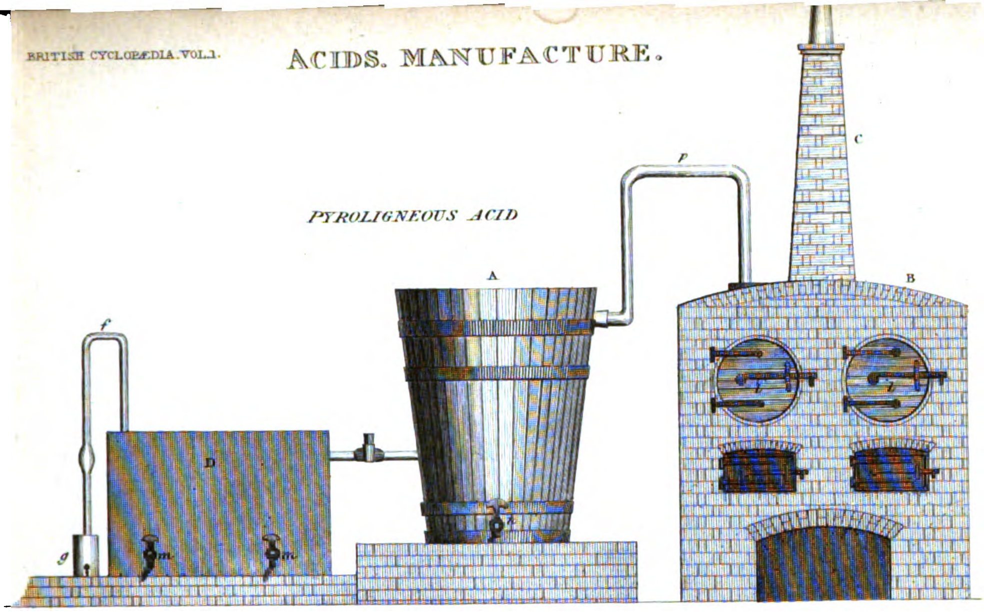
The residue in the retort will be no longer fuming, and is the common oil of vitriol of commerce.

Sulphuric acid is manufactured on the large scale in this country by the combustion of sulphur, which, as we have already seen, converts it into sulphurous acid gas. This gas passes into large leaden chambers, the bottom of which is covered with about six inches of water; together with the sulphurous acid gas, a quantity of the vapour of nitrous acid passes into the leaden chamber. These two acids have the property of uniting together; and they form minute crystals, which fall into the water at the bottom of the chamber. The moment they come in contact, a decomposition takes place; the sulphurous acid is converted into sulphuric acid, and the nitrous acid into deutoxide of azote. This last substance makes its escape in the gaseous state; but immediately comes in contact with the common air of the chamber, and is converted into nitrous acid, which, uniting with a new dose of sulphurous acid, falls again into the water. These decompositions and new formations continually go on as long as the air of the chamber contains oxygen gas and sulphuric acid. The water, when sufficiently impregnated with sulphuric acid, is drawn off from the bottom of the chamber, and concentrated as far as possible in leaden boilers. It is then put into glass or platinum retorts, and kept in a heat of at least 600°, till as much concentrated as possible.

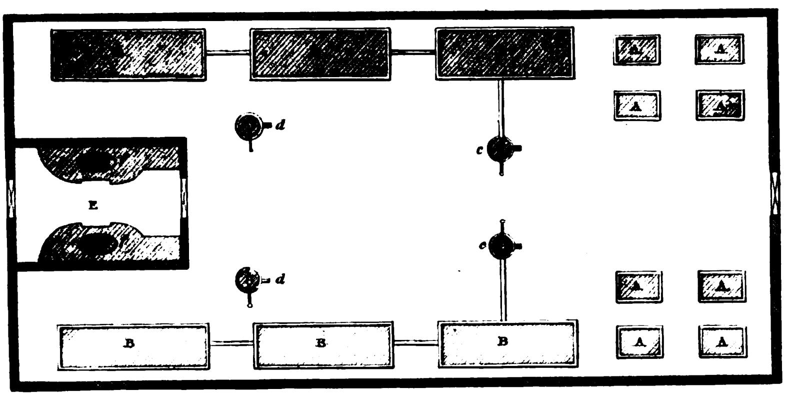
A plan of the arrangement of a large sulphuric acid works is shewn in our plate, ACIDS' *Manufacture*, in which B B are the leaden chambers containing water, and through which the gas passes. A A

ACIDS. MANUFACTURE.

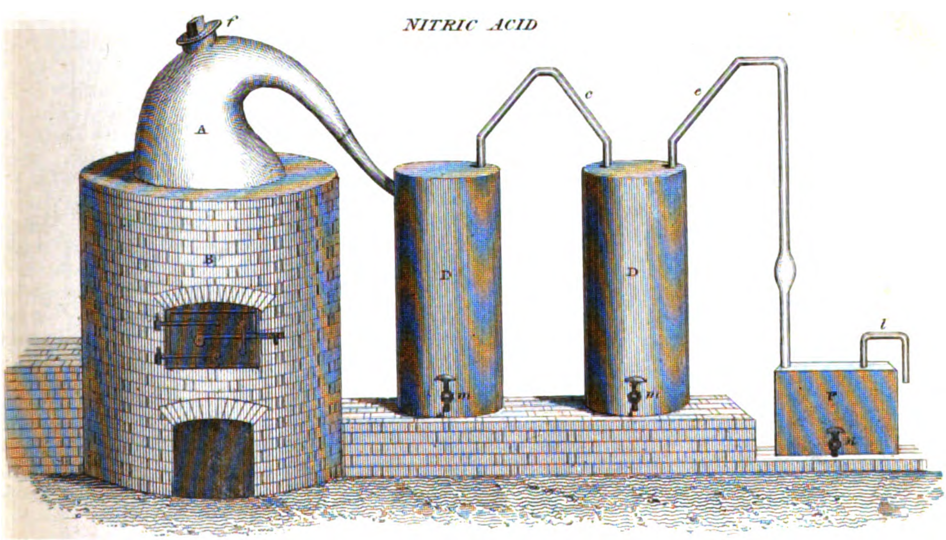
PYROLIGNEOUS ACID



SULPHURIC ACID



NITRIC ACID



London, Published by William Orr, Paternoster Row, Sept.r 29. 1832.

are the boilers of the same material, in which the acid is concentrated prior to its being evaporated in the platinum retorts. The pumps for drawing off the weak acid is shewn at *c c*, *d d*, and the retort room, &c. at E, *f f*.

Acid thus prepared, is a clear, transparent, colourless liquid like water, with a certain degree of consistency, so as to adhere to the sides of a phial like oil. When quite free from all impurity, its specific gravity (when as strong as possible) is 1·847; if it be heavier than this, it is contaminated with lead.

Nitrous Acid.—The next compound in order of practical importance is the nitrous acid, which may be produced by adding oxygen to the deutoxide of nitrogen. The experiment will not succeed over water or mercury, but may be conducted in a glass retort, fitted with a stop-cock, from which the air has been extracted by an exhausting syringe. In this way a mixture may be made of 2 measures of the deutoxide, and 1 measure of oxygen, which will be condensed into half their volume, and form a deep orange-coloured gas: 2 volumes of the deutoxide are composed, as we have seen,

1 volume of nitrogen, and
1 volume of oxygen,

and 1 volume of oxygen now added, form 2 volumes of oxygen to 1 of nitrogen in the composition of nitrous acid.

A taper will burn in this gas, and phosphorous most vividly. Charcoal also burns in it with a dull red light.

Water dissolves it, and acquires a green tint, which changes to blue, and finally to yellow, as more of the gas is absorbed. The solution is sour, reddens litmus paper, and stains animal substances yellow. It has been called liquid nitrous acid; but with regard to this solution, there is some ambiguity.

Nitric Acid.—This acid may readily be produced by passing the deutoxide of nitrogen *very slowly* into oxygen gas, standing over water. By this operation, four volumes of the former combine with three of the latter; and the compound, therefore, must consist of 2 volumes nitrogen, and 5 volumes oxygen.

The acid as it is formed is absorbed by the water, and it is very doubtful whether it can be exhibited in an insulated state.

The liquid nitric acid is of very great importance in the arts, and is used in large quantities. It is procured, for commerce, by distilling nitre with strong sulphuric acid: the product is an intensely acid liquid, which, when pure, is colourless, and when most concentrated has a specific gravity of 1.5; that is to say, it is by half heavier than water. In this state it contains 25 per cent. of water; which is the least quantity with which it is known to exist.

In the plate, Acids' *Manufacture*, is given a view of the apparatus employed in preparing this acid. A is a large iron pot with earthenware head and plug at *f*. Two iron vessels receive the acid, and are provided with earthenware stop-cocks. The iron vessels are united by the pipes *c e*, and a third vessel containing a safety-pipe *l*, dipping in water, completes the apparatus.

In this state it is called *hydro*-nitric acid (from a Greek word, signifying water), to denote this combination. In entering into other compounds, it abandons the water and combines in the dry, or, as it is termed, the *anhydrous* state.

It may be *mixed* with water in any proportions beyond the 25 per cent.

The nitric acid is a highly corrosive fluid, and acts as a powerful cautery when applied to the skin, which it stains of a permanent yellow. It is decomposed, with great violence, by most substances which have an affinity for oxygen; which element enters so largely into its composition. If it be brought into contact with hydrogen, at a high temperature, a violent detonation will be the consequence; but the experiment is dangerous, and should not be made without great caution. When poured upon warm, dry charcoal in powder, combustion ensues, with the emission of copious fumes of deutoxide of nitrogen. Spirits of turpentine may be inflamed by suddenly pouring nitric acid upon it: the acid should be poured out of a phial attached to a long stick, or there would be danger to the eyes of the operator.

Muriatic Acid.—Chlorine and hydrogen may be mixed together; and if carefully excluded from the light of day, will remain without change. If the mixture be made with equal volumes of the two, and exposed to light, they will gradually combine; the chlorine will lose its peculiar colour and smell, and a powerfully acid gas will result, without any change of volume. If the mixture be made in a stout phial, with a well-fitted stopper, secured by wrapping a cloth round the neck, and exposed to the direct rays of the sun, the combination will take place suddenly and with detonation. When the stopper is afterwards withdrawn under mercury, it will be found that no condensation has taken place; but if under water, it will instantly rush in and fill the phial, as the new compound is rapidly absorbed by that liquid. The mixture may also be exploded by flame or the electric spark.

To this compound the name of muriatic acid has been given, and it is sometimes called hydrochloric acid. As the elements combine without condensation, its specific gravity must be the mean between those of its two ingredients.

Carbonic Acid.—Carbonic acid is most conveniently obtained by dropping fragments of marble or chalk into muriatic acid, diluted with two or three times its weight of water. A strong effervescence ensues, the gas from which may be collected over the water-bath.

This gas is colourless and inodorous. It is rather more than by one-half heavier than common air; 100 cubic inches weighing 46.5 grains. It is perfectly uninflammable, and instantly extinguishes flame. From its great specific gravity, it will remain for some time at the bottom of a jar with its mouth turned upwards; and may be poured from one such vessel into another like water. It is an amusing experiment to place a lighted taper in the bottom of the jar, as it will be instantly extinguished by pouring the gas upon it, like a liquid.

It is speedily fatal to animals which breathe it: and hence the danger of exposure to the fumes of burning charcoal, which have in so many instances proved fatal. From its great density, it also not unfrequently collects in the bottoms of wells and mines, while the upper parts are free from it, and, from its injurious effects, is called by the miners *choak damp*. It has been condensed into a liquid by a pressure amounting to that of 36 atmospheres, or a column of mercury 90 feet in height.

Water, under common circumstances of pressure

and temperature, will dissolve about its own bulk of this gas; but the quantity taken up may be increased by pressure, and will, in fact, be in exact proportion to the compressing force. It is by the strong compression of a forcing-pump that the common soda-water is so highly charged with this gas.

The solution has an agreeable subacid taste, and reddens paper stained with the blue colour of litmus. When, however, an infusion of litmus, which has been reddened by this acid, is boiled, the blue colour returns as the acid escapes; an effect which distinguishes it from all other bodies of the same class. The pleasant pungency of brisk and sparkling fermented liquors is owing to the carbonic acid which they hold in solution, and which they lose upon exposure to the air, and become thereby flat and stale.

Carbonic acid is produced in all the common cases of combustion, and is likewise abundantly formed during the respiration of animals; it is not, therefore, surprising that it should be always present in the atmosphere to the amount of about one-thousandth or one-fifteen-hundredth of its bulk. Indeed, the great wonder is, considering the abundance of its sources, that it does not accumulate to a greater extent.

Pyroligneous Acid.—This very important acid body is procured by the distillation of wood in iron retorts. Great quantities of pyroligneous acid is collected with little or no trouble during the preparation of charcoal for gunpowder; but it is empyreumatic and impure, and several processes have been contrived to free it from tar and other matters which it contains. It may be saturated with chalk, and evaporated, by which an impure acetate of lime will be obtained, and which mixed with sulphate of soda furnishes, by double decomposition, sulphate of lime and acetate of soda: the latter, distilled with sulphuric acid, produces the acetic acid of commerce.

A very perfect apparatus, combining the manufacture of charcoal with that of pyroligneous acid, is shown in plate Acids' *Manufacture*. A is the worm or condensing tub placed in the centre of the figure, and B, the retort furnace. The wood is introduced at the doors *b b*, and the carbonization effected by fire applied beneath, the chimney C being employed to carry off the vapour. The impure pyroligneous acid passes by the pipe *p* into the worm tub A, and from thence into the large receiver D. The carburetted hydrogen gas, and other uncondensable matter passes off by the bent tube *f g*.

Pyroligneous acid is now employed to a considerable extent in the preservation of meat. In this case the rough acid is found to impart the same flavour to pork and mutton which they would derive from a previous smoking, so that they at once become converted into ham.

Hydro-Fluoric Acid.—There is a substance well known in mining districts, called *fluor spar*. It is found crystallized in cubes of various colours, green, yellow, and purple; and a compact variety of the same substance, the product of Derbyshire, is worked into splendid ornamental vases. If this mineral be reduced to powder, mixed with twice its weight of strong hydro-sulphuric acid, and subjected to distillation, a powerful and highly corrosive liquid acid may be obtained. For this purpose a leaden or silver retort and receiver must be employed; and while a moderate heat is applied to the former, the latter must be kept cool by pounded ice or snow. The hydro-fluoric acid thus formed must be preserved in silver or leaden bottles, with stoppers of the same materials. It is extremely volatile, and not easily confined. In appearance it resembles oil of vitriol. Its specific gravity, when first prepared, is 1.06, but is increased by the gradual addition of water to 1.25; and there is no known instance of a similar condensation. It is necessary to use great caution in experimenting with this substance, as its vapours are highly irritating, and, when applied to the skin, it disorganizes it so rapidly as to occasion dangerous ulcers. In addition to the usual properties of a powerful acid it acts strongly on glass, and corrodes it deeply. Plates of glass, covered with a composition of bees-wax and turpentine, may be drawn upon with a graver, and those parts which are laid bare may be perfectly etched by exposure either to the vapour or the diluted acid.

Hydrocyanic or Prussic Acid.—If a narrow tube be filled with fragments of the saline body called cyanuret of mercury, and placed in a horizontal position, when a stream of sulphuretted hydrogen gas is passed through it, a double decomposition ensues: the sulphur of the gas combines with the metal, black sulphuret of mercury is formed, and the cyanogen which is liberated enters into a new combination with the hydrogen. The product may be expelled by a very gentle heat, and collected in a receiver kept cool by ice. A similar product may be obtained by moistening the cyanuret of mercury with muriatic acid, and distilling at a low temperature. The hydrocyanic acid thus obtained is a colourless liquid, possessing a strong odour resembling that of peach blossoms. In its pure state it is intensely poisonous, and a single drop of it placed upon the tongue of a dog causes almost instant death. When greatly diluted with water, it has the taste of bitter almonds, which, in fact, owe their flavour to a small portion of this acid. Water distilled from the leaves of the laurel also derives its poisonous quality from the presence of the same ingredient. The vapour of the pure acid takes fire on the approach of flame, and when mixed with oxygen gas detonates with the electric spark. It is extremely volatile, and boils at 79° Fah.; and at 0° it congeals. When a drop of it is suffered to fall upon a piece of glass it becomes solid; the cold produced by its rapid evaporation being sufficient to freeze what remains. Hydrocyanic acid reddens litmus paper feebly, and forms salts with the different salifiable bases. Owing to the tendency of its component elements to form other arrangements, it is very liable to spontaneous decomposition, and it is not easy to preserve it from change even out of the contact of the air in well-stopped bottles. The diluted acid is sometimes used in medicine, and it may be proper to add that an itinerant exhibitor of chemical experiments, named Chaubert, has lately been in the habit of swallowing large quantities of what he called prussic acid without producing any fatal effects.

Acidulous, in *Chemistry*, slightly acid.

Acnua, a Roman measure of land equal to about a quarter of an English acre.

Acoustics. One of our most important connexions with external objects is maintained through the sense of hearing; that is, by an affection which certain actions or motions, in those objects, produce on the mind, by being communicated to it through the ear. The peculiar excitation or motion perceptible by

the ear is called *sound;* and the consideration of this motion, its qualities and transmission, forms the science of acoustics. Philosophers distinguish between sound and noise: thus those actions which are confined to a single shock upon the ear, or a set of actions circumscribed within such limits as not to produce a continued sensation, are called a *noise;* while a succession of actions which produce a continued sensation are called a *sound.* It is evident from the mechanism of the ear, so far as it is understood, that it is a refined contrivance for conveying a motion from the medium which surrounds it to the auditory nerve; and that this nerve must receive every motion excited in the tympanum. Every motion thus excited, however, does not produce the sensation of sound. That motions may be audible, it is necessary that they impress themselves upon the medium which surrounds the ear with velocities comprised within certain limits. These motions are commonly produced by disturbing the equilibrium which exists between the parts of a body. Thus, for example, if we strike a bell, the part which receives the first impulse of the blow is driven nearer to the surrounding parts; but, the impulse having ceased, it is urged back by a force of repulsion which exists in the metal, and made to pass beyond its former position. By the operation of another property of the metal, namely, cohesive attraction, it is then made to return in the direction of its first motion, again, beyond its position of repose. Each of these agitations influences the adjacent parts, which, in turn, influence those beyond them, until the whole mass assumes a tremulous motion; that is, certain parts approach to and recede from each other; and it only recovers its former state of repose, after having performed a number of these sonorous vibrations. It is evident that such vibrations as are here described must result from the combined operation of attraction and repulsion, which, together, constitute the elasticity of solid bodies. When fluids, whose elasticity is confined to repulsion, emit sounds, a force equivalent to that of attraction in solids is supplied to them by external pressure. The sonorous vibrations of bodies are exceedingly curious, and the more difficult to be understood from our habits of measuring changes or motions by the sight; but these motions affect very sensibly another organ, while they are almost imperceptible to the eye; and, as we are without the means of converting the ideas derived from one sense into those derived from another, the sensation of the motion of sound does not assist us to understand its precise nature, as compared with visible motions. Thus, the ear at once perceives the difference between a grave and an acute sound; but it is only from attentive observation by the eye, that we discover the different rapidity of succession in the vibrations which produce them. The vibrations of a great many bodies, as strings, bells, and membranes, when emitting sounds, may, however, be distinctly seen, and even felt; but they may often be rendered more sensible to the eye by a little artifice, such as sprinkling the vibrating body with sand, or some light, granular substance.

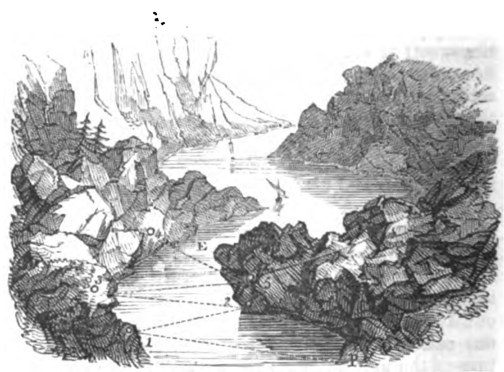
Sound may be produced without vibrations or alternations; thus, if we pass the nail quickly over the teeth of a comb, the rapid succession of single shocks or noises produces all the effect of vibrations. It must be evident that the rapid motions here described, whether originating in vibrations, or a succession of concussions, must be communicated from the body, in which they are excited, to the sheet of air, or whatever else be in contact with it, and from this again to another sheet beyond the first; thus diffusing the motion in every direction. The agitation of the sounding body must thus be communicated to the surrounding medium to a great distance, and impressed upon any body situated within this distance; if this body be the ear, the tremor excited in it by these agitations will be perceived by the mind. The necessity of some medium for the transmission of sound is proved by experiment. If a bell be rung in an exhausted receiver, the sound will be hardly perceptible, while the tones will become clear and distinct, on re-admitting the air.

Having thus given a general outline of the source and propagation of sound, we shall proceed to consider some of the more important facts connected with them.—The most obvious characteristics, by which we distinguish different sounds, consist of differences in their degrees of what we call loudness, and acuteness, or *pitch.* We can produce, at pleasure, sounds having different degrees of loudness, from the same sonorous body, by making the concussions upon it more or less violent; disturbing in a greater or less degree the arrangement of its parts. So two bodies of like substance and figure, but unlike mass, when subjected to the same shock, emit sounds unlike in loudness; and, again, bodies of like mass and figure, but unlike substance, form sounds more or less loud, when subjected to the same shock. In this latter case, the loudness has a relation to the quantity of elasticity possessed by the bodies; and in all cases, when the disturbance of the parts is carried beyond the elastic power of the body, so as to produce a permanent change of figure, no increase of loudness is induced. From a consideration of the preceding facts, we may conclude, that loudness depends upon the quantity of motion, or sonorous vibration, in which it originates. The other principal characteristic of sound, its acuteness or pitch, depends upon the frequency with which the concussions or vibrations of the sonorous body succeed each other. That sounds may be audible to a common ear, it is necessary that the concussions upon the medium, which communicates them, should follow each other in such succession, that not more than 8192, nor less than 32, distinct concussions shall be made upon the medium during the lapse of one second. Some ears, however, can perceive sounds emanating from vibrations a little beyond the extremes to which the perceptions of other ears are confined. We should be careful not to confound the frequency of vibrations with the velocity of vibratory motion. A string may vibrate with a greater or less velocity, as it passes its axis to a greater or less distance; yet the times of its vibrations may be all equal. The difference of velocity, affecting the quantity of motion only, would produce no change, except in the loudness of the sound. To those sounds which proceed from infrequent vibrations, we give the name of *grave* or *low;* those from frequent vibrations we call *sharp* or *acute.* When vibrations succeed each other in equal times, their sound excites a pleasant sensation, and they are called *musical.* When two bodies are made to sound together, if their vibrations are performed in equal times, the sounds are said to be in *unison.* When the vibrations are performed in unequal times, so that some of those of the one are not accompanied by those of the other, the ear perceives a degree of dissonance in the sounds.

If, however, the vibrations meet after short and regular intervals, the dissonance is not easily detected, and the sounds are said to *accord*. During the continuance of most primary sounds, however excited, we perceive other and more acute sounds, co-existing with them. These are called their *harmonics*. They are supposed to originate in a series of secondary vibrations, more short and frequent than the principal vibration. Thus a sounding string, for example, may be supposed not to pass its axis in a simple curve, but to resolve itself into a torturous line, formed by a number of smaller curves, each of which vibrates across its own axis, thus producing its harmonics. It is perhaps some combination of the harmonics with the primary sound, that characterizes the sound of different instruments, though of the same loudness and pitch, so that we can distinguish one from another.

The air, being the common medium which surrounds the ear, is that by which sounds are usually transmitted. This transmission is performed with a velocity of about 1130 feet in a second. All other bodies, however, are capable of transmitting sound. It may be done perfectly, even by the solid parts of the head. If, for example, we hold the stem of a watch between the teeth, and cover the ears with the hands, the beats are heard more distinctly than when the instrument is held at an equal distance in the air. The rubbing together of two stones under water may be heard, by an ear in the same medium, at the distance of half a mile. When the air, or any other body of indefinite extent, is disturbed, in a point situated within it, by a sonorous vibration, it forms a wave which passes from the disturbed point, as a centre, in every direction. It follows that as the wave extends itself, the mass to be put in motion increases until the original motion is rendered insensible from the magnitude of the mass to which it has communicated itself. The velocity with which waves, thus formed, move through any homogeneous elastic medium, is always equal to that which a heavy body would acquire by falling through half the height of the modulus of elasticity.* In applying this law to the transmission of sound by the air, it was for a long time found not to give the same results as were obtained by experiment. The discrepancy, however, has been most ingeniously reconciled by a small correction for the latent heat made sensible by the compression; the effect of this being to increase the height of the modulus of elasticity. We ought, therefore, to find that liquids, and more especially some of the solids, should transmit sound much more rapidly than air; and this agrees most perfectly with various experiments. Cast-iron, for example, has been found to transmit sound with a velocity $10\frac{1}{2}$ times greater than air. Sound does not readily pass from one medium to another; a sound made in the air is not easily distinguished under water, although the distance be very small. It is from this, probably, that cork and all soft cellular bodies are bad conductors of sound, as in these the sound must, in passing through the walls of the cells and the air contained in them, change successively from one medium to another. All sounds, whatever be their loudness or pitch, are transmitted with the same velocity; a fact most completely proved by every musical performance. Were it otherwise, indeed, this beautiful art could not exist. To make this apparent, it is only necessary to consider, that harmony is a combination of different sounds, arranged with certain relations of time and pitch. Now, if one sound were transmitted with greater velocity than another, these relations would differ at different distances, or be confounded, except at a single given point. Nay, further; melody, which is a succession of single sounds, would not reach different ears with the same relations of time, if the different notes were not transmitted with equal velocities. Some observations on sound, in very high latitudes, seem to contradict the above law of transmission. The seeming anomaly, however, is sufficiently reconciled by supposing the different strata of air, through which the sounds, in those instances, were transmitted, in very different hygrometrical or thermometrical states, which would make corresponding differences in their modulus of elasticity. When a wave of sound meets an elastic surface, it is partly transmitted and partly reflected. This reflection, when it returns back perpendicularly, is called an *echo*. That an echo may be distinctly heard, it is necessary that the reflecting surface be at such a distance that the original sound shall have ceased before the reflected one returns to the ear; otherwise they will be blended, and the echo not perceived.

One of the most singular and distinctly marked illustrations of the reflection of sound forming a natural echo, occurs on the banks of the Rhine near Lurley. By referring to the accompanying picturesque illustration, the reader will readily understand how the reverbrations of sound are produced.



P, is considered as the phonic centre, the primary point of radiation for the sound, and the waves striking at the first series of numerals, are reflected to twenty, and so on through the series of reflecting points. Dr. Granville's account of this natural phenomenon, is accompanied by such just remarks on the improved views of science now promulgated, even in the humblest classes of society, that it cannot but prove acceptable to our readers. Between St. Goar, and the ruins of Schonberg, at a spot where the Rhine, from the direction of its deep sinuosities, assumes the appearance of successive and isolated island lakes, bounded all round by upright gigantic rocks, or sloping hills, clad with vines to their very summits: the postilions suddenly checked their career, and turning the wide end of their bugles to the reach of the river we had just passed, blew loud and strong their post-boy tune, and then held their breath. Quickly the musical sounds were

* The height of the modulus of elasticity of air is 27,800 feet.

heard repeated once in a clear and distinct manner, not far from us; and again, a second and a third, and even a fourth time, but as if from a progressively increasing distance, until they died away. The experiment more than once repeated, proved equally successful. We were assured that the repetitions of the sound are more numerous when the experiment is made in a boat placed midway between the two banks.

It is not to be expected that so remarkable and striking a phenomenon should go without being converted into an allegorical tale, during the ages of ignorance and superstition. How, in fact, was this never-failing repetition of the fisherman's choired morning prayer and evening song, which some invisible voice responded in the distant space as he glided over the bosom of the water, to or from his daily toil, to be accounted for? Imagination, ever ready to plunge into the supernatural, created a lovely nymph, and placed her abode on the rock of Lurley, from the sides of which the sounds are principally reverbrated. A dangerous eddy lies on the broad shadow of this rock, and many a time, when the amazed boatman tracked his way through the stream, listening to the mysterious voice from the height of Lurley, his frail bark drawn within the vortex, would miserably perish under the rocky dwelling of the syren. Attracted by the reports of her beauty, and spurred on by the proclaimed cruelty of her disposition, the youthful son of the Count Palatine, of a neighbouring country, determined on seeing the virgin of Lurley, and carrying her a captive to his father's court. His fate was sad; for on arriving, escorted by a few followers, in the agitated waters of Lurley, his boat whirled round and disappeared. Grieved at the loss of his child, the Palatine count dispatched a trusty band to seize the relentless nymph; and just as their rude leader, unmoved by her heavenly charms and dishevelled tresses, was in the act of summoning her to surrender, a sudden hurricane swelled the stream, the waves, crested with foam, rose to the top of the rock, and encircling the lovely Undine, saved her from the rude grasp of man, and carried her to the realm of her fathers. Her voice is still heard returning the song of merriment or sorrow, but her beauteous form appears not on the heights of Lurley.

In this short legend we can trace the working of the mind, under the influence of the heart. Those were not times for the march of intellect, but for that of the passions. Hence the Age of Romance. But now that the heart has lost its influence on the actions of men, under the management of societies for diffusing useful knowledge, and of mechanical institutes—now that the sixpenny treatises on natural philosophy, on hydraulics, and acoustics, all perspicacious and free from errors, enable the commonest understanding to explain on the simplest principles what was before a complicated phenomenon—the echo of Lurley would be accounted for by the singular disposition of the two elevated banks of the river, following parallel lines in a serpentine direction—thus presenting to the rays of sound more than one reflecting surface. This disposition of the two banks, which are here in some parts scarcely more than 1,000 feet asunder, while it accounts likewise for the formidable eddies which are observed in this place, explains how intricate and dangerous the navigation must necessarily be; nay, fatal too, if the careless boatman, less watchful of his course, passes his time in calling on Lurley to repeat his "halloos."

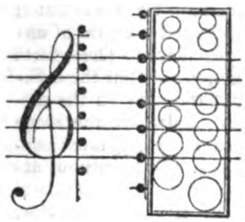
The science of acoustics, like the other physical sciences, has been in a constant state of advancement since the revival of learning. It appears that Pythagoras knew the relation between the length of strings and the musical sounds which they produce. Aristotle was not only aware of this relation, but, likewise, that the same relation subsists between the length of pipes and their notes, and that sound was transmitted by the atmosphere. This constituted the sum of ancient learning in this branch of science. These facts were taught by Galileo, and, moreover, that the difference in the acuteness of sounds depends on the different frequency of vibrations, and that the same string, if of uniform thickness and density, must perform its vibrations in equal times. But, without attempting a history of modern discoveries in acoustics, we can only mention, that the names of Taylor, Moreland, Newton, Daniel Bernoulli, D'Alembert, Euler, Robison, Lagrange, Laplace, Chladni, T. Young, and Biot, are all connected with it. Of these, Newton gave the law of transmission, which we have stated in this article; and the correction for heat was made by Laplace.

The vibrations immediately dependant on elasticity are those of rods, plates, rings, and vessels. These admit of much greater variety, and are of more difficult investigation than the vibration of chords. A rod may be either wholly loose, or fixed at one end only, or at both; and it may either be loosely fixed, in situation only, or firmly fixed, in direction as well as in situation; and these conditions may be variously combined with each other; the rod may also have a variety of secondary vibrations besides the principal or fundamental sound. All these cases have been examined by various mathematicians; the subject was begun by Daniel Bernoulli, and much extended by Euler, some of whose conclusions have been corrected by Riccati; and Chladni has compared them all with experiment. The sounds produced by the same rod, either under different circumstances, or as harmonics which may be heard at the same time, are scarcely ever related to each other in any simple proportion, except that when a rod is loosely fixed at both ends, the frequency of the vibrations of the subordinate notes is expressed by the series of the squares of the natural numbers, as 1, 4, 9, and 16. But the times occupied by any similar vibrations of rods, similarly circumstanced, are always directly as the squares of their lengths, and inversely as their depths. When the rod is wholly at liberty, two, at least, of its points must be at rest, and these are at the distance of about one-fifth of its length from either end, in the next sound of the same rod, the middle point is at rest, with two others near the ends. There is by no means the same regularity in the progress of the vibrations of rods of different kinds, as in those of chords; it can only happen in particular cases, that the rod will return after a complete vibration to its original state, and these cases are probably such as seldom occur in nature.

The vibrations of rings and of vessels are nearly connected with those of plates, but they are modified in a manner which has not yet been sufficiently investigated. A glass or a bell divides, in general, into four portions vibrating separately, and sometimes into six or eight; they may readily be distinguished by means of the agitations excited by them in a fluid

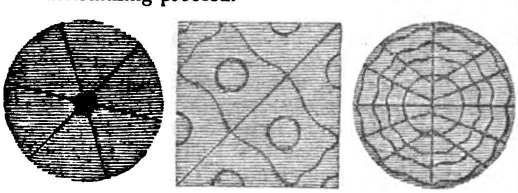
contained in the glass. It is almost unnecessary to observe, that the fluid thus applied, by adding to the mass of matter to be moved, makes the vibration slower and the sound more grave.

Vessels formed of glass are sometimes so arranged as to form a very pleasing musical instrument, and the editor generally uses one in his public lectures, in which the glasses are tuned by grinding their convex surfaces beneath.



The arrangement of the glasses, as originally suggested by Dr. Arnott, is shown in the accompanying figure. The small open circles represent the mouths of the glasses standing in a mahogany case, and the relation of the glasses to the written musical notes, is shown by the common music lines and spaces which connect them. The learner discovers immediately that one row of the glasses produces the notes written upon the lines, and the other row, the notes between the lines; and he is mentally master of the instrument by simple inspection. This arrangement also renders the performance easy, for the notes most commonly sounded in succession are contiguous: and the relations of the notes forming a simple air are so obvious to the eye, that the theory of musical combination and accompaniment is learned at the same time. The set of glasses here represented has two octaves, and the player stands at the side of the case with the notes ascending towards the right hand, as in the piano-forte.

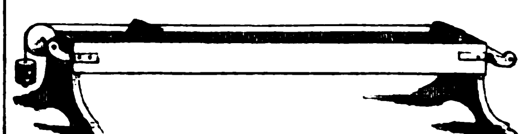
The vibration of plates differs from those of rods in the same manner as the vibrations of membrane, differ from those of chords, the vibrations of which cause the plate to bend in different directions, being combined with each other, and sometimes occasioning singular modifications. These vibrations may be traced through wonderful varieties by Professor Chladni's method of strewing dry sand on the plates, which, when they are caused to vibrate by the operation of a bow, is collected into such lines as indicate those parts which remain either perfectly or very nearly at rest during the vibrations. Dr. Hooke had employed a similar method, for showing the nature of the vibrations of a bell, and it has sometimes been usual in military mining, to strew sand on a drum, and to judge, by the form in which it arranges itself of the quarter from which the tremors produced by countermining proceed.



The above figures show some of the least complex arrangements produced by water on a glass plate—the plate being put into vibration by a violin bow. If a screen be placed a few feet higher than the plate, and a strong light beneath, the figures may be rendered visible to a large audience.

It usually happens that the vibration of a cord deviates from the plane of its first direction, and becomes a rotation or revolution which may be considered as composed of various vibrations in different planes, and which is often exceedingly complicated. These vibrations may be combined, in the first instance, in a manner similar to that which has been already explained respecting the vibrations of pendulums; and if the motion of the chord be supposed to follow the same law as that of a pendulum, the result of two entire vibrations thus united, may be either a vibration in an intermediate direction, or a revolution in a circle or in an ellipsis. But, besides these compound vibrations of the whole chord, it is also frequently agitated by subordinate vibrations, which constitute harmonic notes of different kinds, so that the whole effect becomes very intricate; as we may observe by a microscopic inspection of any luminous point on the surface of the chord; for instance, the reflection of a candle in the coil of a fine wire wound round it. The velocity of the motion is such, that the path of the luminous point is marked by a line of light, in the same manner as when a burning coal is whirled round; and the figures thus described, are not only different at different parts of the same chord, but they often pass through an amusing variety of forms during the progress of the vibration; they also vary considerably according to the mode in which that vibration is excited.

A very useful instrument for ascertaining the effects of length and pressure, with reference to a vibrating string, is shown in the figure. The string is firmly attached at one extremity to the projecting arm, and passing over a bridge somewhat nearer to the centre, is strained by the weight and pulley at the opposite end. A second moveable bridge is seen near the pulley by which the length is regulated.



Under the head of *organ-pipe*, we purpose giving the theory of wind instruments generally; but the following collection of curious facts, bearing upon the general principles of acoustics, are too important to be omitted in our general view of the science.

The resonances of sound, or reciprocated vibrations of columns of air, has been fully examined by Mr. Wheatstone, and we cannot do better than give the result of his observations on this interesting part of acoustics. An elastic body may be made to assume a vibratory state in two ways; either immediately, by any momentary impulse, which altering the natural positions of its particles, allows them afterwards to return by a succession of isochronous oscillations to their former state; or secondarily, by means of an immediately sounding body, which causes it to reciprocate to the latter, when certain conditions, on which depends its susceptibility of vibrating in such a manner, are fulfilled. This reciprocation to which, where the effect is referred to, the term *resonance* is applied, is effected by means of the undulations which are produced in the air, or in any fluid or solid medium, by the periodical pulses of the original vibrating body; these undulations being capable of putting in motion all bodies whose pulses are coincident with their own, and consequently with those of the primitive sounding body. Galileo observed, that a heavy pendulum might be put in mo-

tion by the least breath of the mouth, provided the blasts be often repeated, and keep time exactly with the vibrations of the pendulum; and this remark affords a correct explanation of the phenomenon.

Some of the most obvious cases of resonance are—the vibrations of a string when another tuned in unison with it is made to vibrate; the resounding of the drinking-glass to the sound of the voice, or of a musical instrument; the reciprocated vibrations of a sounding-board, communicating immediately with a vibrating string or tuning-fork, &c. In the last-mentioned instance, though the string and the fork are the original vibrating bodies, the audible sound is dependent on the resonance of the sounding-board.

If one of the branches of a vibrating tuning-fork be brought near the embouchure of a flute, the lateral apertures of which are stopped so as to render it capable of producing the same sound as the fork, then the feeble and scarcely audible sound of the fork will be augmented by the rich resonance of the column of air within the flute. The sound will be found greatly to decrease by closing or opening another aperture; for the alteration of the length of the column of air in such case renders it no longer proper to reciprocate perfectly the sound of the fork. This experiment may be easily tried on a concert flute, with a C tuning-fork. To ensure success, it is necessary to remark, that when a flute is blown into with the mouth, the under lip partly covering the embouchure, renders the sound about a semi-tone flatter than the sound when the embouchure is entirely uncovered; and as the latter must be unison to that of the tuning-fork, it is necessary, in most cases, to finger the flute for B when a C tuning-fork is employed.

A similar effect may be produced by substituting for the column of air in the flute, the alterable volume of air contained within the cavity of the mouth. Mr. Wheatstone found the sounds of tuning-forks reciprocated most intensely by placing the tongue, &c. in the position for the nasal continuous sound of *ng* (in song), and then altering the aperture of the lips until the loudest sound is obtained.

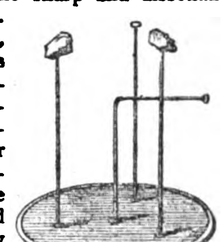
A column of air may also reciprocate a sound originally produced by a wind instrument, as the following experiment will show. Place two concert flutes on a table, parallel to, and at a short distance from each other; on the one which is nearer, sound C sharp (all the lateral apertures being open), and draw out the tube of the second flute, so that it shall be about a semi-tone flatter, to make it equivalent to the flattening of the first flute by the partial closing of the embouchure by the lip; a material difference will then be distinguished in the intensity of the tone by alternately closing and opening the first hole of the more distant instrument, thereby rendering it incapable or capable of reciprocating the original sound. That this effect is occasioned solely by the transmission of the sonorous undulations, and not by any wind actually blown into the second flute is evident from the difference being in intensity and not in pitch.

This experiment may be varied by placing the fipple of a flageolet at a short distance from the embouchure of a flute, provided of course, that the columns of air, both in the flageolet and the flute, be capable of producing the same note.

Among the Javanese musical instruments brought to England by the late Sir Stamford Raffles, there is one called the "Gender," in which the resonances of unisonant columns of air are employed to augment the sounds of vibrating metallic plates. Of these plates there are eleven; the sounds correspond with the notes of the diatonic scale, deprived of its fourth and seventh, and extend through two octaves. The mode of vibration of the plates, is that with two transversal nodal lines; and they are suspended horizontally by two strings, one passed through two holes in the one nodal line, and the other through similar holes in the other nodal line of each plate. Under each plate is placed an upright bamboo, containing a column of air, of the proper length to reciprocate the lowest sound of the plate. If the aperture of the bamboo be covered with pasteboard, and its corresponding plate be struck, a number of acute sounds only (depending on the more numerous subdivisions of the plate) will be heard; but on removing the pasteboard, an additional deep, rich tone is produced by the resonance of the column of air within the tube.

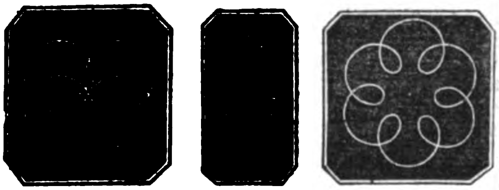
The Gender from which the annexed drawing was taken is at present in the museum of the Honourable East India Company; and there is another specimen in the possession of Lady Raffles.

If a rod be firmly fixed at one end, and allowed to vibrate freely through its whole length, tones of a very peculiar kind are found to result. Thus, a rod only two feet in length will give a tone as deep as that of the bell employed in the church of St. Paul; and the Parisian clock-makers have availed themselves of this fact, in the construction of their ornamental chimney clocks, which, by this means, cost less, and strike without the sharp and dissonant tinkle common to light bells.

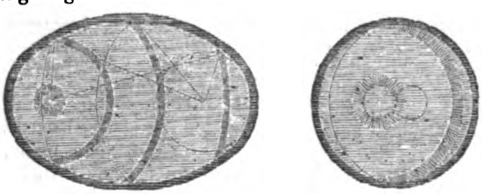


A very pretty instrument, called a "Keleidophone," has been contrived by Mr. Wheatstone, of which the accompanying cut is a representation. It consists of four vibrating rods, on which variously formed bodies are placed, and very beautiful and vivid figures produced by merely drawing either of the rods out of the perpendicular, and then allowing

them to vibrate freely. Quicksilvered glass beads reflect the light of a lamp, or the sun-beams better probably than most other objects; but Mr. Wheatstone showed the editor the letters on a common address card, and which, when attached to a bent rod, produced two most elegant compound figures. The white lines beneath show the paths of a series of these rods.

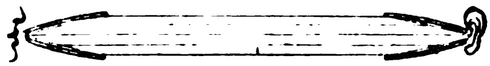


If a sound or a wave be reflected from a curved surface, the new direction which it will assume may be determined either from the condition that the velocity with which the impulse is transmitted must remain unaltered, or from the law of reflection, which requires that the direction of the reflected pulse or wave be such as to form an angle with the surface, equal to that which the incident pulse before formed with it. Thus, if a sound or wave proceed from one focus of an ellipsis, and be reflected at its circumference, it will be directed from every part of the circumference towards the other focus; since the distance which every portion of the pulse has to pass over in the same time, in following this path, is the same, the sum of the lines drawn from the foci to any part of the curve being the same; and it may also be demonstrated that these lines form always equal angles with the curve on each side. The truth of this proposition may be easily shown by a simple experiment on a bason of water; the curvature of a circle differs so little from that of an ellipsis of small eccentricity, that if we let a drop fall into the bason near its centre, the little wave which is excited will be made to converge to a point at an equal distance on the other side of the centre. The effects of these reflections are perfectly illustrated in the accompanying diagrams.



An umbrella held in a proper position over the head, may serve to collect the force of a distant sound by reflection, in the manner of a hearing trumpet; but its substance is too slight to reflect any sound very perfectly, unless the sound fall on it in a very oblique direction. The whispering gallery of St. Paul's produces an effect nearly similar by a continued repetition of reflections. Mr. Charles's paradoxical exhibition of the Invisible Girl has also been said to depend on the reflection of sound; but the deception is really performed by conveying the sound through pipes ingeniously concealed, and opening opposite to the mouth of the trumpet from which it seems to proceed.

The speaking and hearing horns owe their operation to the reflection of sound. The reader has already seen how capable a continuous pipe is of transmitting the waves or pulses of the air. This is also, to a certain extent, accomplished by a trumpet-mouthed vessel, and a second apparatus may be employed to collect the pulses which have thus been transmitted.



The above figure shows at one view the joint effects of both forms of the trumpet. The organs of *voice* and *hearing* will be found under those heads.

Acre, a measure of superficies, and the principal denomination of land-measure in use throughout the whole of Great Britain. The word (formed from the Saxon *æcer*, or the German *acker*, a field) did not originally signify a determinate quantity of land, but any open ground, especially a wide campaign; and in this antique sense it seems to be preserved in the names of places, as Castle-acre, West-acre, &c. The English standard acre, now the imperial acre of Britain, is determined from a square, each of whose sides is the chain of 66 feet, or 22 yards, or 1-80th of a mile. Ten of these squares form the acre, which thus contains 4840 square yards. This is divided into roods, of which there are four in the acre; and into poles or perches, of which there are 40 in each rood, or 160 in the acre. The rood will thus measure 1210 square yards, and the pole 30¼ square yards.

The above is the standard acre of England; but various customary acres are in use throughout the different counties, deviating considerably from this standard both in excess and defect, though all of them are now illegal since the act 5 George IV., which establishes the same standard throughout the whole kingdom. In Bedfordshire, it is sometimes only two roods; Cheshire, formerly, and still in some places, 10,240 square yards; Cornwall, sometimes 5760 yards; Dorsetshire, generally 134 perches; Hampshire, from 107 to 120 perches, but sometimes 180; Herefordshire, two-thirds of a statute acre. The acre for hops contains 1000 plants, and is only equal to half a statute acre; for wood, again, it is 256 perches. Leicestershire, 2308¾ square yards; Lincolnshire, five roods, particularly for copyhold land; Staffordshire, nearly 2¼ acres; Sussex, 107, 110, 120, 130, or 212 perches; the short acre 100 or 120 perches, the forest acre 180 perches. Westmoreland, 6760 square yards, or 160 perches of 6½ yards square; in some parts the Irish acre is used: Worcester, the hop acre, of 1000 stocks, 90 perches, sometimes 132 or 141 perches.

In North Wales, the *Erw* or true acre is 4320 square yards, the *Stang* or customary acre 3240 square yards, as in Anglesea and Caernarvonshire, making 5¼ Llathen, = 160 perches of 4½ yards square, called *paladr:* 8 acres make an *ox-land*, and 8 of these a *plough-land*, in Pembrokeshire. In South Wales the Erw varies greatly with the perch; sometimes this is nine feet square, 160 perches making one stangell, and four stangells one erw of 5760 yards; sometimes 10½ feet square, making a quart or quarter of a llath, 40 of which make a stangell, and four stangells an erw, which is thus 7840 yards, equal to the Irish acre; sometimes 11 feet, called bat or eglwys haw, making the erw 9384 yards, as in Glamorganshire, one-fifth more = 11,261 yards; sometimes 11½ feet, called a llath, 48 making a quarter cyvar, and four

cyvars an erw of 11,776 yards; lastly, 12 feet, giving an erw of 10,240 yards, equal to the Staffordshire acre.

Nothing can show more clearly than the existence of such numerous and useless diversities, the necessity of the late act for establishing a uniform standard throughout Great Britain, and which only requires to be enforced with strictness to abolish for ever every other measure. In Scotland the acre is much more uniform, scarcely deviating in any part more than one per cent. from the standard.

Acroteria, or Acroters, small pedestals usually without bases, placed in the middle and at the two extremities of pediments, and serving also to support statues. The same term was also applied to the figures placed as ornaments on the summits of public edifices.

Action, is that motion which one body produces or endeavours to produce in another. Mechanical action is exerted either by percussion or by pressure; and, in either case, the force exerted by the acting body is repelled in an equal degree by the body on which it acts. Thus, in driving a nail with a hammer, the stroke acts as powerfully against the face of the hammer as against the head of the nail; and in pressing the hand upon a stone, the pressure upon the stone is equally great with that upon the hand. In each of these cases the impulse is counteracted by what is termed the re-action; and that action and re-action are always equal, is not only laid down as an axiom in mechanics, but is understood to be a general law of nature.

Active Force, see *Force*.

Actus, a term used by Vitruvius as a measure of 100 Roman feet in length. It was also applied in agriculture to the length of one furrow, or the distance traversed by a plough in one continued line.

Acupuncture, a surgical operation, which is performed by the insertion into the part affected of a silver or golden needle. It is practised to a large extent by the Chinese and Japanese, who employ it beneficially in cases of headache, lethargy, convulsion, colic, and other maladies. It has been introduced into this country, and resorted to with great advantage, particularly in hydrocephalous diseases, in which Dr. Conquest has employed it with eminent success.

Acute Angle. See *Geometry*.

Acute, in *Music*, is used to express the quality of a tone which is sharp or high in comparison with some other. It is thus opposed to *grave*.

Addition, the first of the four operations of *Arithmetic*, which see.

Additions, in *Heraldry*, are a species of bearings in coat armour, in which are placed rewards or additional marks of honour.

Adductors, an anatomical term, applied to those muscles which draw together the parts into which they are inserted.

Adhesion, according to the latest phraseology of physics, means generally the tendency of heterogeneous bodies to adhere together; but *cohesion* implies the attraction of homogeneous particles of bodies. Adhesion may take place between two solids, as two hemispheres of glass, or between a solid and a fluid, or between two fluids, as oil and water. Thus it is said that a fluid adheres to a solid, as water to the finger dipped into it. But there is a great difference, in this respect, in different bodies; thus small particles of quicksilver do not adhere to glass, but they adhere to gold, silver, and lead, in consequence of chemical attraction. Water adheres to the greatest part of bodies, unless it is separated from their surface by oily substances, dust, flour, &c. Fluids do not form a surface perfectly horizontal in vessels to which they adhere so as to wet them, but rise, on the contrary, around the brim of the vessels. This is proved by fluids poured into glasses, &c. Fluids, on the other hand, in vessels to which they do not adhere, sink around the brim, and rise in the centre. Thus quicksilver in a glass forms a convex surface. This phenomenon of the rising and sinking of fluids becomes still more remarkable in vessels of a small diameter; wherefore capillary tubes, so called, are used for performing experiments, and the singular effects produced are ascribed to capillary attraction.

Adhesion should, strictly speaking, be divided into two kinds. The one, a species of natural attraction which takes place between the surfaces of bodies, whether similar or dissimilar, and which, in a certain degree, connects them together; the other, the joining or fastening together of two or more bodies by the application of external force.

With respect to the first-mentioned, it has been proved, that the power of adhesion is proportionate to the number of touching points; and this, in solid bodies, depends upon the degree in which their surfaces are polished and compressed. The effects of this power are extremely curious, and, in many instances, astonishing.

Musschenbrœck relates, that two cylinders of glass, whose diameters were not quite two inches, being heated to the same degree as boiling water, and joined together by means of melted tallow lightly put between them, adhered with a force equal to 130 lbs; that lead of the same diameter, and in similar circumstances, adhered with a force of 275 lbs.; and soft iron with a force of 300 lbs.

Martin, in the *Philosophia Britannica*, states, that with two leaden balls, not weighing above a pound each, nor touching upon more than one-thirtieth of a square each surface, he has lifted more than 150 lbs. weight; and that the force of adhesion between two brass planes, each four and a quarter inches in diameter, and smeared with grease or fat, was so great, that he never could meet with two men strong enough to separate them by pulling against each other. In the first experiment, the balls were scraped very finely with the edge of a sharp pen-knife, and then equally pressed together with a considerable force and a gentle turn of the hand.

We may now notice the adhesion of nails. Every carpenter is familiar with the use of the nail, and possesses a practical knowledge, more or less accurate, of the force of adhesion of different nails, and in different substances, so as to decide, without difficulty, what number, and of what length, may be sufficient to fasten together substances of various shapes, and subject to various strains. But, interesting as this subject unquestionably is, it has not been till very recently that the necessary experiments have been made to determine, 1st. the adhesive force of different nails when driven into wood of different species; 2d. the actual weight, without impulse, necessary to drive a nail a given depth; and 3d. the force required to extract the nail when so driven. The obtaining this useful knowledge was reserved for Mr. B. Bevan, a gentleman well known in the me-

chanical and scientific world, for the accuracy with which his experiments are conducted.

Mr. Bevan observes, that the theoretical investigation points out an equality of resistance to the entrance and extraction of a nail, supposing the thickness to be invariable; but as the general shape of nails is tapering towards the points, the resistance of entrance necessarily becomes greater than that of extraction: in some experiments he found the ratio to be 6 to 5.

The following table exhibits the relative adhesion of nails of various kinds, when forced into dry Christiana deal, at right angles to the grain of the wood.

Description of Nails used.	Number to the lb. Avoirdupois.	Inches forced into the wood.	Pounds requisite to extract.
Fine Sprigs . . .	4560	0·40	22
Ditto	3200	0·44	37
Threepenny brads .	618	0·50	58
Cast iron nails . .	383	0·50	72
Sixpenny nails . .	73	1·00	187
Ditto	—	1·50	327
Ditto	—	2·00	530
Fivepenny nails . .	139	1·50	320

The percussive force required to drive the common sixpenny nail to the depth of one inch and half into dry Christiana deal, with a cast iron weight of 6.275 lbs., was four blows or strokes falling freely the space of 12 inches; and the steady pressure to produce the same effect was 400 lbs.

A sixpenny nail driven into dry Elm, to the depth of one inch across the grain, required a pressure of 327 pounds to extract it; and the same nail, driven endways or longitudinally into the same wood, was extracted with a force of 257 pounds.

The same nail driven two inches endways into dry Christiana deal, was drawn by a force of 257 pounds; and to draw out one inch, under like circumstances, took 87 pounds only. The relative adhesion, therefore, in the same wood, when driven transversely and longitudinally, is 100 to 78, or about 4 to 3 in dry elm; and 100 to 46, or about 2 to 1 in deal: and in like circumstances, the relative adhesion to elm and deal is as 2 or 3 to 1.

The progressive depths of a sixpenny nail into dry Christiana deal by simple pressure were as follows:

One quarter of an inch, a pressure of	24 lbs.
Half an inch	76 —
One inch	235 —
One inch and half	400 —
Two inches	610 —

In the above experiments, great care was taken by Mr. Bevan to apply the weights steadily, and towards the conclusion of each experiment, the additions did not exceed 10 lbs. at one time, with a moderate interval between, generally about one minute, sometimes 10 or 20 minutes. In other species of wood, the requisite force to extract the nail was different. Thus, to extract a common sixpenny nail from a depth of one inch out of

Dry oak, required . . .	507 lbs.
Dry beech	667 —
Green sycamore	312 —

From these experiments, we may infer that a common sixpenny nail, driven two inches into dry oak, would require a force of more than half a ton to extract it by a steady force.

A common screw, of one-fifth of an inch, was found to have an adhesive force of about three times that of a sixpenny nail.

The force necessary to break or tear out a half-inch iron pin, applied in the manner of a pin to a tenon in the mortice, has likewise obtained the attention of the same ingenious experimentalist. The thickness of the board was 0·87 inch, and the distance of the centre of the hole from the end of the board 1.05 inch. The force required was 979 lbs.

As the strength of a tenon from the pin-hole may be considered in proportion to the distance from the end, and also as the thickness, we may, for this species of wood, obtain the breaking force in pounds nearly, by multiplying together one thousand times the distance of the hole from the end by the thickness of the tenon in inches.

The adhesion of glue is no less important in a practical point of view. Mr. Bevan glued together by the ends two cylinders of dry ash wood, one-fifth of an inch in diameter and about eight inches long; after they had been glued together 24 hours, they required a force of 1260 pounds to separate them; and as the area of the circular ends of the cylinders were 1.76 inch, it follows that the force of 715 pounds would be required to separate one square inch.

It is right to observe, that the glue used in this experiment was newly made, and the season very dry. For in some former experiments on this substance, made in the winter season, and upon some glue which had been frequently made, with occasional additions of glue and water, he obtained a result of 350 to 560 pounds to the square inch.

The present experiment, however, was conducted upon a larger scale, and with greater care in the direction of the resultant force, so that it might be, as near as practicable, in a line passing at right angles through the centres of the surfaces in contact. The pressure was applied gradually, and was sustained two or three minutes before the separation took place.

Upon examining the separated surfaces, the glue appeared to be very thin, and did not entirely cover the wood, so that the actual adhesion of glue must be something greater than 715 pounds to the square inch.

Mr. Bevan also tried the lateral cohesion of fir-wood, from a scotch fir of his own planting, cut down in the autumn, sawn into boards, and at the time of experiment, quite dry and seasoned. The force required to separate the wood was 562 pounds to the square inch; consequently, if two pieces of this wood had been well glued together, the wood would have yielded in its substance before the glue.

From a subsequent experiment, made on solid glue, the cohesive force was found to be 4000 pounds per square inch; from which it may be inferred, that the application of this substance as a cement is susceptible of improvement.

Adipocire, from *adeps*, fat, and *cera*, wax; a substance of a light-brown colour, formed by the soft parts of animal bodies, when kept for some time in water, or when preserved from atmospheric air. When this substance is subjected to a chemical analysis, a true ammoniacal soap is first yielded, composed of ammonia, a concrete oil, and water. The oil may be obtained pure, and this is called more strictly

adipocire. It was discovered on removing the animal matter from the burial ground of the church *des Innocens*, at Paris, in 1787, amongst the masses of the bodies of the poor there interred together. In this place, about 1500 bodies were thrown together into the same pit, and, being decomposed, were converted into this substance. In the crypt, beneath the ancient church of St. Martin-le-Grand, several human bodies have been found converted into adipocire. (See *Nicholson's Journal*, vol. 4, p. 135; *Phil. Trans.* 1794, vols. 84, 85; *Journal de Physique*, tom. 38, &c.)

Adit, the shaft or entrance of a mine.

Adjunct, in *Music*, a term expressive of the relation between the principal mode, and the modes of its two-fifths, which, from the intervals that constitute the relation between them and it, are called its adjuncts.

Adnata, in *Anatomy*, one of the coats of the eye, also called conjunctiva and albuginea.

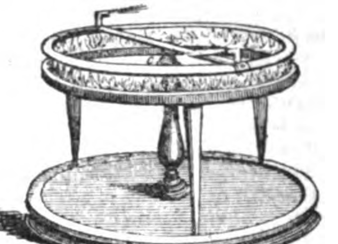
Adustion, a surgical operation of the same nature as cauterization, and consisting in the application of a burning substance to the part affected.

Æginetan Style and Monuments of Art. An association of English and German artists and lovers of the arts was formed in 1811, chiefly with a view of obtaining an architectural survey of the temple of Jupiter Panhellenius, at Ægina, which is one of the most beautiful remains of the Doric architecture. A sketch of this temple may be found in the *Journal of Science*, and in the *Isis*, a periodical edited by Oken, in Germany. This undertaking was amply rewarded by a fine collection of valuable sculpture, which once adorned the eastern and western fronts of that noble edifice. It was purchased by the king of Bavaria in 1812, and the deficient parts restored by Thorwaldson. Every member of the association received a cast of it carefully executed in plaster of paris. These works are valuable as faithful imitations of nature, and for the light which they shed over one of the darkest periods in the history of art. They show that the Æginetan style of art was independent of the Attic. Pausanias calls Smilis the Dædalus of Ægina, assures us that he was the contemporary of Dædalus, and ascribes therefore to the Æginetan style equal antiquity and independence with the Attic. The language and manners of Ægina were Doric; and its sculpture has a Doric character, as distinct from the Attic (which was originally Ionic) as Doric poetry and architecture. The characteristic peculiarity and aim of the Æginetan style is the faithful and exact imitation of nature, carried even to deception. Attic art was a daughter of the Ægyptian, and a striving after the ideal is perceptible in both. To gain a clear idea of primitive art, we must distinguish between the Ægyptian, ancient Attic, Æginetan, and Etrurian styles. Rudeness, stiffness, and meagreness belong to the first attempts in every art. In other respects, they differ from one another, although, at a later period, they exercise a mutual influence. The perfection of art in Phidias has hitherto appeared almost a miracle; but we now comprehend how the Æginetan school, imitating nature with almost perfect exactness, pointed out the way to the ancient Attic, teaching it to rise from the abstract to the living, from the conventional to the natural. Thus we find the long-desired link of connexion between the ancient severe and beautiful styles. Since the creations of Phidias, the traces of the proper Æginetan style have disappeared. There was subsequently, therefore, only one perfect style of art, which spread over all Greece; and *Æginetan* became the name for primitive sculpture. Smilis was the father and founder of the Æginetan style of art; next to him came Callon, who lived between the 60th and 70th Olympiads (540—500 B. C.) About the time of Phidias, there lived the following masters, famous in this style: Anaxagoras, who made the Jupiter which was placed in Olympia at the common expense of all the Greeks, who fought victoriously at Platæa, B. C. 379; Simon, the maker of the consecrated offering of a certain Phormis at Olympia; and Glaucius and Onatas, who flourished in the 78th Olympiad. The Æginetan figures now exhibited at Munich are 17. They may be divided into 4 classes: 1, upright, clothed, and female; 2, advancing or fighting combatants; 3, kneeling, or archers; 4, lying, or wounded. The largest of these figures is Minerva. She is a little above the human size; all the others are rather below this measure. If we consider the style of these works, there prevails in every part of the bodies, the head excepted, a minute imitation of nature, without the least traces of the ideal. Still the imitation is neither poor nor offensive to the rules of art, but a good copy of beautiful nature, with the most perfect knowledge of the bones and muscles. With respect to proportion, these figures are slender, rather small at the hips, and the legs remarkably long. There is much life in the attitudes, though they are not altogether free from a certain stiffness, such as may be observed in the paintings of Giotto, Masaccio, Perugino, &c. The heads seem to belong to an earlier epoch of art; the eyes project, and are lengthened somewhat in the Chinese fashion; the mouth has prominent lips, with well marked edges; the corners in some are turned up; the nose is rather small; the ears finished with the greatest care; the chin is full, and generally too large. They all look alike, and exhibit not the slightest expression of passion; between conquerors and conquered, gods and men, there is not the least difference. The appearance of the hair is not natural, but stiff and conventional. The arms are rather short; the hands natural to deception; not a wrinkle of the skin is forgotten. The legs are well shaped; the knees masterly; the feet elegant; and the toes, which are rather too long, run out parallel. The drapery is close to the body, with folds artificially arranged. Though the style is hard, the execution is tasteful and elaborate. They were apparently made at the same time, but not by the same artist. No one of them has any support, and they are equally finished on all sides. The number of figures originally amounted to 30, at least. They were symmetrically arranged on both fronts of the temple. The Minerva stood in the middle, the standing warriors next, then the archers, and the lying figures last. The temple was not intentionally destroyed, but was probably thrown down by an earthquake. Since Æacus erected this temple to Jupiter Panhellenius, it is probable that the figures represent the battles of the Æacidæ, under the protection of Minerva. The two contests in which the Æacidæ distinguished themselves most gloriously, were the Trojan war and the naval battle of Salamis: in the latter, the images of the Æacidæ of Homer, Ajax, and Telamon, were displayed, and regarded as supernatural protectors. According to another opinion, the group of the eastern front represented the contest around the body of Laomedon, king of Troy and the

one on the western, that around the body of Patroclus. The figures should probably be assigned to a period between the 60th and 80th Olympiads. Pindar calls Ægina the "well-fortified seat of the Æacidæ," probably referring to these images, for no one of the sons of Æacus then remained in the country. The marble of which they are wrought is Parian, of the kind usually called *Grechetto*. The colours perceptible here and there on the figures are vermillion and azure. All the decorations and foliage of the temple, which are generally carved, were painted. The niches of the fronts in which these figures stood were azure, the partitions red, the foliage green and yellow, and even the marble tiles were painted with a kind of flower. We cannot call this system of painting barbarous; we find it even on the Parthenon. Winckelmann was the first who conjectured the existence of an ancient school of art in Ægina, from the accounts of Pausanias. (See *Wagner's Bericht uber die Æginetische Bildwerke, herausgegeben und mit kunstgeschichtlichen Anmerkungen begleitet, von Schelling*, 1817; *Wagner's Report on the Æginetan Remains of Art*, &c.) Subsequently, K. Otfr. Muller, in his learned and acute work, *Æginæticorum Liber*, Leipsic, 1820, attempted to determine their relation to the other monuments still extant; and Thiersch to investigate their mythological signification. Against the idea of a peculiar Æginetan style of art, deduced from these marbles, Henry Meyer wrote in Goethe's *Kunst und Alterthum*, 3 *Bd*. 1. *Heft*., and opposed the derivation of Grecian sculpture from the Egyptian as strenuously as Winckelmann advocated it.

ÆOLIAN HARP, or ÆOLUS'S HARP, was introduced into England about the middle of the last century. It is generally a simple box of thin fibrous wood (often of deal), to which are attached a number of fine catgut strings, sometimes as many as 15, of equal size and length, and consequently unisons, stretched on low bridges at each end. Its length is made to correspond with the size of the window or other aperture in which it is intended to be placed; its width is about five or six inches, its depth two or three. It must be placed with the strings uppermost, under which is a circular opening in the centre as in the belly of the guitar. When the wind blows athwart the strings, it produces the effect of a choir of music in the air, sweetly mingling all the harmonic notes, and swelling or diminishing the sounds according to the strength or weakness of the blast. A more recent Æolian harp, invented by Mr. Crossthwaite, has no sounding-board, but consists merely of a number of strings extended between two deal boards. The invention of the Æolian harp has been generally ascribed to father Kircher, but the fact is, that it was known and used at a much earlier date in the East, as Mr. Richardson has proved, in his *Dissertation on the Manners and Customs of the East*.

ÆOLIPILE. This instrument was employed for domestic purposes at a very early period. It usually consists of a spherical ball of metal, with a pipe of small bore through which a jet of steam may be impelled. To put it in operation, the ball is, in the first instance, filled with water, and then heat applied to its external surface. As soon as the fluid boils, the steam is impelled from the mouth of the tube with great violence, and the apparatus thus constructed, forms a very good substitute for the ordinary bellows. On a larger scale, it is sometimes used to increase the draft of a steam engine furnace, as a jet of high pressure steam will carry with it a great deal of air, and when directed against the lower bars of the furnace, materially increase the effect of the fire.



In the above wood-cut a machine is represented employed by the editor in his public lectures, in which the æolipile is made to revolve. It consists of a circular tube formed into one continuous ring, and supported by a pointed steel axis. Two small bent tubes are seen to rise from the upper part of the ring, and when fire is applied beneath, the steam rushes from the apertures, and acting like the common rocket wheel, produces a continuous rotatory motion.

A beautiful modification of the revolving æolipile may now be adverted to. It is shown in the above figure, and is intended to illustrate the principle on which Hero of Alexandria is said to have constructed a steam engine, giving motion to small automata. In the latter case, the fire was applied above, and the air expanded, or spirituous vapour formed by the heat. A small tube, passing through the centre of the temple, was furnished with tubes and horizontal apertures, as in the former instance; and as the figures were attached to the thin plate beneath, their rotatory motion was the result.

ÆRIFORM, a term used to denote bodies which are airlike or gaseous. See *Gas*.

ÆROLITHS, or meteoric stones, the name given to those mineral substances which occasionally fall through the atmosphere to the earth. The concordance of a multitude of facts seems to render it indisputable, that certain stony and metallic bodies have

at various periods fallen to the earth; but the rarity of this phenomenon was for a great length of time a powerful obstacle to belief in the minds of the learned. It was long believed that they presented one of the forms assumed by thunder in its descent, and they were then considered as the products of the explosion of certain luminous balls which are sometimes observed during a thunder-storm. The first of these peculiar substances, which seems to have been examined with any degree of minuteness, was the stone presented, in 1768, to the Academie Royale des Sciences, by M. l'Abbé Bachelay, and which, when found, was still hot. The academicians analysed it, and were induced to conclude that it did not fall from the heavens, and that it was nothing but a species of pyrites which had lain covered by a thin stratum of earth until struck by the lightning and exposed to view. The attention of the philosophers of this country was first called to this subject by the fall of one of these masses, weighing 55 lbs., which occurred in 1795, near Wold Cottage, in Yorkshire; and a similar and more striking phenomenon happening three years afterwards at Benares in the East Indies, it began to excite the greatest interest. During the public exhibition of the former, which succeeded its discovery, Sir Joseph Banks observed a resemblance between it and a substance of a similar nature, which he had received as one of the stones which fell at Sienna, about eighteen hours after the celebrated eruption of Vesuvius, in 1794. He immediately procured a specimen, and submitted it for analysis, together with a portion of his Italian stone, to an able chemist, Mr. Edward Howard. This gentleman subsequently obtained specimens of the Benares stone, and also of one in the cabinet of the right honourable Charles Greville, which fell in 1753, at Plann, in Bohemia; both of which, together with the others, underwent a most minute examination. They all appeared to have the same character, and to be intimately related; their surfaces were of a dark colour, and consisted of a semivitrified and blistered crust; and when broken, they exhibited an ash-grey stony appearance, intermixed with spangles of pyrites and of native iron. They seemed to be composed principally of substances of four kinds, independently of their external coating of oxide of iron; the first being in the form of dark grains, consisting of silica, magnesia, iron, and nickel; the second, of a species of pyrites, composed of sulphur, iron, nickel, and a portion of extraneous earthy matter; the third, of metallic iron, and the fourth of a grey earthy material, which served as a cement to the others, and which consisted of the same materials in almost the same proportions as the first substance. The proportions of these bodies varied in the different specimens, the iron abounding most in those which were obtained from Yorkshire and Benares. The examinations of Mr. Howard were afterwards repeated and verified by Vauquelin and Klaproth.

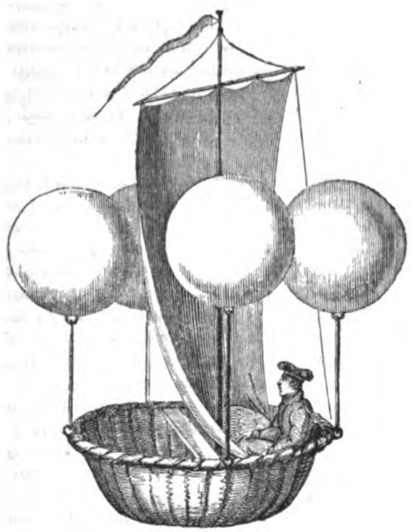
A considerable analogy exists between what is termed native iron and the substances we have just described; it is in many cases combined with another metal, nickel, which is always an ingredient in those masses called meteoric stones, which have been actually seen falling in the air. Hence a similar origin has been assigned to both; and Pallas describes a block of this iron found on the top of a mountain in Siberia, which the Tartars considered as a sacred relic which had dropped from heaven. There is now in the Imperial Museum of Vienna a large mass of aerial iron, which was actually seen to fall through the atmosphere in a state of incandescence; this occurred in Croatia, in 1751. Mr. Howard examined specimens of several masses of native iron, and from the results of his experiments, in which he coincided with Proust, he seems to think it not impossible that their origin may be the same with that of meteoric stones.

Although philosophers have devoted much of their attention to the investigation of the nature and origin of these bodies, yet we are at the present moment as ignorant of the part of space in which they are formed, and of the manner of their formation, as we were at the very commencement of the inquiry. As there were no analogous phenomena which could indicate the formation of hard metallic substances within the limits of our own atmosphere, it was natural to seek for their origin in the nearest of the planets; and hence it has been very generally maintained by many distinguished individuals that meteoric stones have their origin in the moon, and that they are by some powerful volcanic agency projected to such a height from her surface as to be more strongly attracted by the earth than by that planet, and consequently to be compelled to continue their course until they arrive at the confines of our atmosphere, and are retarded in their velocity by its resistance. This hypothesis was supported in France by Laplace, and the inflammation and combustion of the stones was attributed to the intense heat which must necessarily be evolved by the great compression of the air which would be produced by the velocity with which these bodies must enter the atmosphere. M. Biot has calculated that an initial velocity, about five times as great as that which a cannon ball sometimes receives, would be sufficient for the projection of a body from a lunar volcano into the limit of the earth's superior attraction, which is situated at nearly one-ninth of the distance of the earth from the moon.

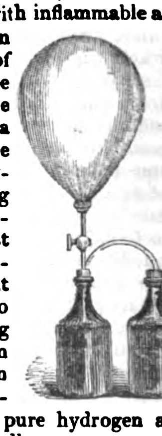
The improbability of the existence of such a high degree of volcanic force in so small a planet as the moon, has led to other speculations, and it has been maintained by some that ærolīths are portions of small invisible planets circulating round the earth; by others, that they are the fragments of a large planet which formerly existed between Mars and Jupiter, and of which the four small planets, Ceres, Pallas, Juno, and Vesta, are the remaining fragments; and lastly, that they are minerals in their primitive state, which have been ejected from the interior of our own globe by volcanoes situated in the polar regions, which produce at the same time the phenomena of the northern lights. The last of these opinions is that of M. de Lagrange, who however coincides in all his views with Dr. Brewster, who previously proposed the hypothesis which derives the origin of these substances from a formerly existing planet. Lagrange supposes the bursting of a planet to be a very probable event; and he has investigated formulæ for computing the velocity with which the fragments of a burst planet must be projected in order to move in elliptical parabolic, or hyperbolic orbits. Assuming the initial velocity of a cannon ball at 1400 French feet per second, he has shown that in the case of a planet situated beyond the orbit of Uranus, a velocity twelve or fifteen times greater than that of a cannon ball would be sufficient to make the fragments move in an ellip-

tical or parabolic orbit, whatever be their dimensions and the directions in which they are projected. A variety of circumstances concur to prove, with an evidence amounting almost to demonstration, that the four small planets, of late years, discovered between the orbits of Mars and Jupiter, are fragments of a large celestial body which once existed, and which may be supposed to have been burst in pieces by an internal force capable of overcoming the mutual attraction of the fragments. When this great convulsion took place, a number of little fragments, detached together with the greater masses, would on account of their smallness be projected with very great velocity; and being thrown beyond the attraction of the larger portions, might fall towards the Earth when Mars happened to be in the remote part of his orbit. They might then revolve about that body at different distances, and might fall upon its surface in consequence of a diminution of their centrifugal force; or, being struck by the electric fluid, they might be precipitated on the Earth, and exhibit all the phenomena which usually accompany the descent of meteoric stones.

Aeronautics; the art of sailing in or navigating the air. The idea of inventing a machine, which should enable us to rise into the air, appears to have occupied the human mind even in ancient times, but was never realized till the last century. The first suggestion for a sailing vessel with any pretensions to the character of science, is due to Francis Lana, a distinguished jesuit. This occurred in 1670; and the arrangement of the apparatus will be best understood by referring to the following figure.



Lana, it will be seen, proposed to support his car by the aid of four balls. These were to be exhausted of air; and the inventor argued that their diminished weight would cause the balls to support themselves and the aëronaut. We notice this apparatus, as similar schemes have been put forth even within our own times; but it must be obvious to any intelligent mind, that the external pressure of the atmosphere would destroy the vessels, even if they could be rendered light enough. Henry Cavendish, having discovered, about 1766, the great levity of inflammable air or hydrogen gas, Dr. Black, of Edinburgh, was led to the idea that a thin bladder, filled with this gas, must ascend into the air. Cavallo made the requisite experiments in 1782, and found that a bladder was too heavy, and paper not air tight. Soap bubbles, on the contrary, which he filled with inflammable air, rose to the ceiling of the room where they burst.—In the same year, the brothers Stephen and Joseph Montgolfier constructed a machine which ascended by its own power. In Nov. 1782, the elder Montgolfier succeeded, at Avignon, in causing a large bag of fine silk, in the shape of a parallelopiped, and containing 40 cubic feet, to mount rapidly upwards to the ceiling of a chamber, and afterwards, in a garden, to the height of 36 feet, by heating it in the inside with burning paper. The two brothers soon afterwards repeated the experiment at Annonay, where the parallelopiped ascended in the open air 70 feet. A larger machine, containing 650 cubic feet, rose with equal success.—They now resolved to make the experiment on a large scale, and prepared a machine of linen, lined with paper, which was 117 feet in circumference, weighed 430 pounds, and carried more than 400 pounds of ballast. This they sent up, June 5, 1783, at Annonay. It rose in tėn minutes to a height of 6,000 feet, and fell 7,668 feet from the place of ascension. The method used to cause it to ascend was, to kindle a straw fire under the aperture of the machine, in which they threw, from time to time, chopped wood. But, though the desired effect was produced, they had no clear nor correct idea of the cause. They did not attribute the ascension of the vessel to the rarefaction of the air enclosed in it by the operation of the heat, but to a peculiar gas, which they supposed to be developed by the burning of the straw and wood. The error of this opinion was not discovered till a later period.—These experiments roused the attention of all the philosophers of Paris. It occurred to some of them, that the same effect might be produced by inflammable air. M. Charles, professor of natural philosophy, filled a ball of lutestring, 12 feet in diameter, and coated with a varnish of gum-elastic, with such gas. It weighed 25 pounds, rose 3,123 feet in two minutes, disappeared in the clouds, and descended to the earth, after three-quarters of an hour, at the village of Gonesse, about 15 miles from Paris. Thus we see two original kinds of balloons; those filled with heated air, and those filled with inflammable air.



The process of filling balloons on the small scale for this species of aërial navigation, will readily be understood by a reference to the accompanying sketch, in which a simple condenser is employed. The common mode is to generate hydrogen gas in a bottle, by pouring dilute sulphuric acid on granulated zinc, but the hot and moist vapour from the acid speedily destroys the balloon. To prevent this, the experimentor has only to employ a second bottle containing water, and carry a bentpipe from the first bottle through a cork in the second, it dips beneath the surface, and is condensed, and the pure hydrogen ascends by the second pipe to the balloon.

To continue, Montgolfier had gone to Paris, and found an assistant in Pilater de Rozier, the superintendent of the Royal Museum. They completed together, in Oct. 1783, a new machine, 74 feet in height,

and 48 in breadth, in which Rozier ventured for the first time to ascend, though only 50 feet. The balloon was from caution fastened by cords, and soon drawn down. Eventually the machine, being suffered to move freely, took an oblique course, and at length sunk down gradually about 100 feet from its starting place.—By this the world was convinced that a balloon might, with proper management, carry a man through the air; and the first aërial expedition was determined on.

Nov. 21, 1783, Pilatre de Rozier and the marquis d'Arlandes ascended from the castle la Muette, in the presence of an innumerable multitude, with a machine containing 6,000 cubic feet. The balloon, after having attained a considerable height, came down, in 25 minutes, about 9,000 yards from la Muette. But the daring aeronauts had been exposed to considerable danger. The balloon was agitated very violently several times; the fire had burnt holes in it; the place on which they stood was injured, and some cords broken. They perceived that it was necessary to descend without delay; but when they were on the surface of the earth, new difficulties presented themselves. The weak coal fire no longer supported the linen balloon, the whole of which fell into the flame. Rozier, who had not yet succeeded in descending, just escaped being burnt.—M. Charles, who had joined with M. Robert, soon after informed the public that they would ascend in a balloon filled with inflammable air. To defray the necessary expense of 10,000 livres, he opened a subscription. The balloon was spherical, 26 feet in diameter, and consisted of silk coated with a varnish of gum-elastic. The car for the aëronauts was attached to several cords, which were fastened to a net, drawn over the upper part of the balloon. A valve was constructed above, which could be opened from the car, by means of cords, and shut by a spring. This served to afford an outlet to the inflammable air, if they wished to descend, or found it necessary to diminish it. The filling lasted several days; and, Dec. 1, the voyage was commenced from the gardens of the Tuilleries. The balloon quickly rose to a height of 1800 feet, and disappeared from the eyes of the spectators. The aëronauts diligently observed the barometer, which never stood at less than 26°, threw out gradually the ballast they had taken in to keep the balloon steady, and descended safely at Nesle. But as soon as Robert stepped out, and it was thus lightened of 130 pounds, it rose again with great rapidity about 9,000 feet. It expanded itself with such force, that it must have been torn to pieces, had not Charles, with much presence of mind opened the valve to accommodate the quantity of gas to the rarity of the surrounding atmosphere. After the lapse of half an hour, the balloon sunk down on a plain, about three miles from the place of its second ascent.

Another ascent, which nearly proved disastrous to the aeronauts, may now be noticed.—On the 15th of July, 1784, the Duke of Chartres, the two brothers Roberts, and another person, ascended with an inflammable-air balloon from the park of St. Cloud, at 52 minutes past 7 o'clock in the afternoon. This balloon was of an oblong form, measuring 55½ feet in length, and 34 in diameter. It ascended with its greatest extension nearly horizontal; and after remaining in the atmosphere about 45 minutes, it descended at a little distance from whence it had ascended, and at about 30 feet distance from the *Lac de la Garenne*, in the park of *Meudon*. But the incidents that happened in this aerial excursion deserve to be particularly described, as nothing like it had happened before to any of the aerial travellers. This machine contained an interior smaller balloon filled with common air; by which means, according to a mode hereafter to be mentioned, the machine was to be made to ascend or descend without any loss of inflammable air or ballast. The boat was furnished with a helm and oars, intended to guide it, &c.

On the level of the sea the barometer stood at 30.25 inches, and at the place of departure it stood at 30.12. Three minutes after its ascending, the balloon was lost in the clouds, and the aërial voyagers lost sight of the earth, being involved in a dense vapour. Here an unusual agitation of the air, somewhat like a whirlwind, in a moment turned the machine three times from the right to the left. The violent shocks which they suffered, prevented their using any of the means prepared for the direction of the balloon, and they even tore away the silk stuff of which the helm was made. Never, said they, had a more dreadful scene presented itself to any eye, than that in which they were involved. An unbounded ocean of shapeless clouds rolled one upon another beneath, and seemed to forbid their return to the earth, which was still invisible. The agitation of the balloon became greater every moment. They cut the cords which held the interior balloon, which consequently fell on the bottom of the external one, just upon the aperture of the tube, which went down into the boat, and stopped it up. At this time the thermometer shewed a little above 44°. A gust of wind from below drove the balloon upwards, to the extremity of the vapour, when the appearance of the sun showed them the existence of nature; but now both the heat of the the sun, and the diminished density of the atmosphere, occasioned such a dilation of the inflammable air, that the bursting of the balloon was apprehended; to avoid which they introduced a stick through the tube that proceeded from the balloon, and endeavoured to remove from its aperture the inner balloon, which closed it; but the dilatation of the inflammable air pushed the inner balloon so violently against the aperture of the tube, that every endeavour proved ineffectual. During this time, they still continued to ascend, until the mercury in the barometer stood not higher than 24.36 inches, which shows their height above the surface of the earth to be about 5,100 feet. In these dreadful circumstances, they thought it necessary to make a hole in the balloon, in order to give an exit to the inflammable air; and the Duke of Chartres, by means of one of the banners, made two incisions, which caused a rent of between seven and eight feet. They then descended very rapidly, seeing at first no object on earth or in the heavens; but a moment after they discovered the fields, and were descending straight towards a lake, into which they must have fallen, had they not thrown overboard about sixty pounds weight of ballast, which occasioned their coming down at about thirty feet beyond the edge of the lake. Notwithstanding this rapid descent, occasioned by the great quantity of gas which escaped out of the two rents in the balloon, none of the four adventurers was hurt; but spoke in the highest terms of excitement of the pleasures of their expedition.

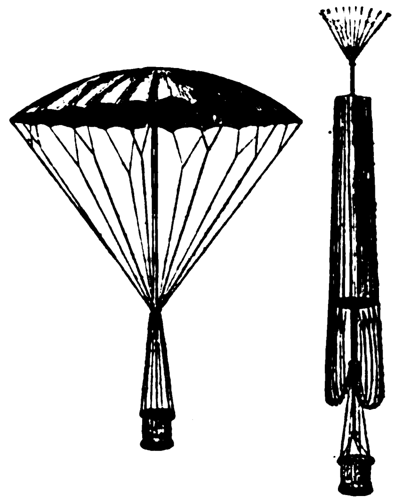
These successful aerial voyages were soon followed by others. Blanchard had already ascended several

times, when he determined to cross the channel between England and France, which is about 23 miles wide, in a balloon filled with inflammable air. He succeeded in this bold attempt, Jan. 7, 1785, accompanied by an American gentleman, Dr. Jeffries. About one o'clock they left the English coast, and at half-past two, were on the French. Pilatre de Rozier, mentioned before as the first aeronaut, attempted, June 14, 1785, in company with Mr. Romain, to pass from the French to the English side; but the attempt was unsuccessful, and the adventurers lost their lives. M. de Rozier had on this occasion united the two kinds of balloons; under one, filled with inflammable air, which did not alone possess sufficient elevating power, was a second, filled by means of a coal fire under it. Rozier had chosen this combination, hoping to unite the advantages of both kinds. By means of the lower balloon, he intended to rise and sink at pleasure, which is not possible with inflammable air; for a balloon filled with this, when once sunk to the earth, cannot rise again with the same weight, without being filled anew; while, on the contrary, by increasing or diminishing the fire under a balloon filled with heated air, it can be made to rise and fall alternately. But this experiment caused the death of the projectors. Probably the coals, which were only in a glowing state near the surface of the ground, were suddenly kindled to a light flame as the balloon rose, and set it on fire. The whole machine was soon in flames, and the two aeronauts were precipitated from the air. The condition of their mangled bodies confirms the conjecture that they were killed by the explosion of the gas.—This unhappy accident did not deter others; on the contrary, the experiments were by degrees repeated in other countries.

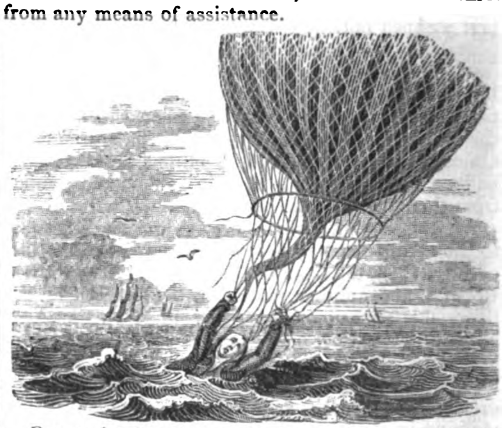
However important this invention may be, it has as yet led to no considerable results. Its use has hitherto been confined to observations in the upper regions of the atmosphere. But should we ever learn to guide the balloon at will, it might, perhaps, be employed for purposes of which we now have hardly an idea; possibly the plan of professor Robison might be accomplished by the construction of a gigantic balloon, which would enable us to perform an aerial circumnavigation of the earth. During the French revolution, an aerostatic institution was founded at Meudon, not far from Paris, for the education of a corps of aeronauts, with the view of introducing balloons into armies as a means of reconnoitring the enemy. But this use of balloons was soon laid aside, for, like every other, it must be attended with great uncertainty, as long as the machine has to obey the wind. Among the French, Blanchard and Garnerin have undertaken the greatest number of aerial voyages; among the Germans, professor Jungius, in Berlin, in 1805 and 1806, made the first. Since that time, professor Reichard and his wife have become known by their aerial excursions. Even in Constantinople, such a voyage was performed, at the wish and expense of the sultan, by two Englishmen, Barly and Devigne. Blanchard has rendered an essential service to aeronauts by the invention of the parachute, which they can use, in case of necessity, to let themselves down without danger.

The arrangement of the parachute, with reference to its use for aeronautic purposes, may now be more fully illustrated.

In the right hand figure, M. Garnerin's apparatus is seen as it ascended from St. George's parade. A cylindrical box, about three feet in height, and two in diameter, was attached by a straight pole to a truck or disc at the top, and from this was suspended a large sheet of linen somewhat similar to an umbrella. The form it assumed on the descent of the aeronaut is shown in the next figure. When first cut from the balloon, it descended with amazing velocity, and those who witnessed its progress considered the destruction of the aeronaut as certain; but after a few seconds the canvas opened, and the resistance was so great, that the apparatus diminished in its speed, till on its arrival near the earth it was not greater than would have resulted from leaping a height of two feet.



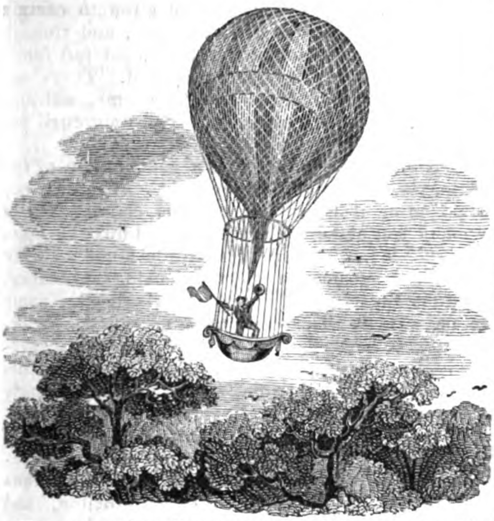
Amongst the unfortunate aeronauts we may place Major Money, who ascended from Norwich, under the full impression that the aerial current would take the balloon in the direction of Ipswich. Scarcely, however, had he attained an altitude of one mile, when a violent hurricane, operating in a new direction, drove the balloon towards Yarmouth. Several small row boats immediately put out from that port, and endeavoured to keep pace with the balloon, but without success, and Major Money first touched the sea about nine miles from land, and more than three from any means of assistance.



Our artist has delineated the situation of Major Money at the period we have now been describing, or rather about ten minutes after he had parted with

a portion of his clothes and instruments; and it was only by the assistance of a fast sailing cutter, which happened to lay in the track of the balloon, that he was saved, when almost exhausted.

Having thus given a brief account of the early history of the aerostatic art, and of the successive improvements which the balloon has undergone both in its external form and appearance, and the nature of the material used for inflation; we may now speak of the very beautiful machines which are employed for aerial excursions by the aeronauts of the present day.



The preceding illustration exhibits a very picturesque view of the ascent of that veteran, Mr. Green, from the Park, on the occasion of the coronation of his late majesty, George IV. The balloon itself, the form of which is similar to, but infinitely more beautiful than a pear, is composed of strips of variegated silk, the harmony of which has a particularly pleasing effect on the eye. Over this is thrown an envelope of net-work, which passing down serves as a support to which the car is attached.

The utility of aeronautic studies and experiments has been very much questioned even by philosophical minds. M. Cavallo, well known in the philosophical world, suggested long ago that small balloons, especially those made of paper, and raised by means of spirits of wine, may serve to explore the direction of the winds in the upper regions of the atmosphere, particularly when there is a calm below; and we see the French aëronauts adopted this idea, that they might serve also for signals in various circumstances, in which no other means can be used; and letters or other small things may be easily sent by them; for instance, from ships that cannot safely land on account of storms; from besieged places, islands, or the like. The larger aerostatic machine, he adds, may answer all the above-mentioned purposes in a better manner; and they may, besides, be used as a help to a person who wants to ascend a mountain or a precipice, or to cross a river; and perhaps one of the machines tied to a boat by a long rope, may be, in some cases, a better sort of sail than any that is used at present. Their conveying people from place to place with great swiftness, and without trouble, may be of essential use, even if the art of guiding them in a direction different from that of the wind should never be discovered. By means of those machines the shape of certain seas and lands may be better ascertained; men may ascend to the top of mountains they had never visited before; they may be carried over marshy and dangerous grounds; they may by that means come out of a besieged place, or an island; they may, in hot climates, ascend to a cold region of the atmosphere, either to refresh themselves, or to observe the ice which is never seen below; and, in short, they may be thus taken to several places, to which human art hitherto knew of no conveyance.

Ærophobia, a term that has been sometimes used for the dread of fresh air. Dr. Franklin says, that he has been sometimes seized with this ærophobia, considering fresh air as an enemy, and excluding it from the rooms which he has occupied. But experience convinced him of his error, and taught him to regard fresh air as eminently conducive to health. Any air, he says, is preferable to that of a close chamber, which has been again and again respired without any change. The same sagacious philosopher has occasionally rallied those valetudinarians, who, wrapping themselves in close garments, hurry from the noxious air of a close chamber, with as much of it as they can carry with them, into as close a carriage, from which the external air is carefully excluded, and thus proceed to take the air for the benefit of their health.

Æruginous, something partaking of, or like to, the rust of copper. Authors do not seem perfectly agreed about the colour to be expressed by this word, some expressing by it green, others brown.

Ærugo, denotes rust, especially that of copper.

Æscaldarium, or cast brass, otherwise called æsolarium, or pot brass, is a species of brass mentioned by Pliny, which was not capable of being hammered. This is likewise a term used by the German mineralists, for a substance which sometimes occurs to those who work upon cobalt, and is used for making the fine blue colour called smalt.

Æs Corinthium, a precious metallic composition, of a much finer colour than common brass, and from its beauty, little inferior to gold. Pliny says (Hist. tom. ii. p. 640. Ed. Hard.), that this was an accidental mixture of metals at the sack and conflagration of Corinth by L. Mummius, 146 years before Christ; when the gold, silver, and brass statues, and all metallic substances, melting and mingling together, formed this mass. He says, that there were three sorts of Corinthian brass, viz. the red, the white, and that which was of the colour of money, according to the different proportions of gold and silver that were in it. But some refiners, who have strictly examined this metal, find no gold in it; a circumstance which, if true, suggests one reason, among others, for concluding, that this account is fabulous. However, the fable has been interpreted by some to signify, that the art of making copper into brass was first discovered by the Corinthians, who found the calamine stone on the plains of Peloponesus, or, at least, that they brought this art to perfection.

Æs Grave denoted money among the Romans, which was paid by weight, and not by tale. In this sense it is used by Buddæus and Scaliger.

But others, by æs grave, understand large pieces of copper coined, containing, for instance, an as, or

pound of that metal, such as we find current in Sweden. These, they assert, bore the title æs grave, till the time in which they were reduced to a smaller standard. Gronovius, on the contrary, maintains, that the as, or pound weight, did not acquire the appellation, æs grave, till after their reduction. (*Philos. Trans.* No. 19.) Kuster rejects all these opinions, and asserts, that the expression is used to denote any kind of copper money compared with gold or silver; which, with regard to the bulk, and size of the pieces, was much lighter, though of greater value.

But this system, however plausible, is rejected by several learned men, particularly Perizonius and Mr. Ward. The former has a dissertation on the subject, in which the opinion of Gronovius is farther examined and defended.

Æs Ustum, called also Æs Veneris,—Æs Cremantum,—Crocus Veneris, and Cinis Æris,—is a term which, like many others among the old chemists, has been applied to two or three different substances; it is, therefore, on this account deservedly rejected from the reformed nomenclature. Hunkel (*Labor. Chem.* p. iii. c. 39) employs it as a general denomination for a perfect oxide of copper prepared by heat; the expression is, however, more commonly employed to denote a pharmaceutical preparation once much in vogue as an escharotic, but now fallen into disuse. This æs ustum essentially consists of copper and sulphur; and the different varieties originate from the relative proportions of the ingredients, and the different states of oxidation of the copper. It is usually prepared by stratifying in a crucible copper clippings and powdered sulphur, and heating the crucible by degrees, till it ceases to emit any vapours; it must then be raised to a dull red heat for an hour; there results a brittle mass, which, when pulverized and washed, is the substance in question.

Barchusen's method is still more simple, consisting merely in heating a slip of copper to whiteness, and rubbing it with a roll of brimstone; as soon as it is taken out of the fire, the copper combines eagerly with the sulphur, and the compound runs down in drops, and is received in a basin of water: this is then pulverized and washed. In both these cases the compound is a slightly oxydated copper, saturated with sulphur; of an iron brown colour. In addition to this process, Lemery goes on to heat the sulphurated oxide in a reverberatory nine times successively, quenching it in linseed oil after each roasting. He thus obtains a product of a high red colour, which, in fact, is a simple oxide of copper, the sulphur being burnt out. Some recommend a mixture of nitre or common salt with the sulphur, and the substance resulting from this, if not washed, is certainly a very powerful escharotic, on account of the sulphurated alkali which is thus combined with the oxide of copper. As to the sal ammoniac and vinegar, in which some previously steep the copper, it is wholly useless, all its effect being destroyed by the subsequent heating. *Dict. Method. Art.* Æs Ustum.

Æsculapius, in *Astronomy*, the ancient name for the constellation Ophincus.

Æther; an extremely fine, subtile, and elastic fluid, which philosophers have supposed to be diffused throughout the universe, and by means of which they have explained many of the great phenomena of nature. It is mentioned by Aristotle. Its existence cannot be proved. Newton believed in it, and explains by it the connexion of the parts of a body, and the laws of gravity. Euler asserts that æther is almost 39,000,000 times thinner, and 1,278 times more elastic, than atmospheric air.

Æther; in *Chemistry*, see Ether.

Ætherial Oil is a fine, subtile, essential oil, approaching nearly to the nature of a spirit. Thus, the pure liquor rising next after the spirit, in the distillation of turpentine, is called the ætherial oil of turpentine.

Ætherial Phosphorus, is a name generally given by Bernoulli, to that otherwise called mercurial, or borometrical phosphorus.

Æthiops, in *Pharmacy*, a name given to certain metallic preparations of a dark colour; and though the term is at present superseded, it is yet too familiar to chemists to be wholly omitted. There are four pharmaceutical articles of this name, æthiops antimonialis, æthiops martialis, æthiops murcurii per se, and æthiops mineralis.

Æthiops Antimonialis, is a combination of the sulphurets of antimony and mercury. The old way of preparing it is, to mix together equal parts of common salt and crude antimony, and flux the mass in a crucible; when cold, there will be found a dusky scoria, resting upon a metallic-looking substance, which is the crude antimony, nearly in the same state as at first. The scoria being separated, the antimony is to be ground with an equal weight of mercury, till they are well united. The first part of this process seems wholly unnecessary, and accordingly the antimonial æthiops is generally made by trituration of crude antimony with an equal weight of mercury. A still more expeditious, and equally efficacious, way of preparing this mixture is, to fuse some crude antimony in an earthenware crucible, and when it is upon the point of fixing, to add to it an equal weight of hot mercury; the mixture immediately becomes more fluid, and after awhile becomes solid: when cold, it must be levigated in a mortar, and washed.

Affinity, in *Chemistry*. When two bodies are brought in contact with each other, they will often, without the sensible operation of any extraneous influences, combine by a spontaneous and reciprocal action, and form new bodies with different properties; a single body, modified by the action of the natural agents, caloric, electricity, &c., sometimes produces the same results; finally, a body not apparently acted upon by other bodies, nor by the natural agents, sometimes acquires new properties, and assumes new forms. These changes in the chemical character of bodies are produced by a force, to which we give the name of *affinity*. Some of the laws or modes of action of this force are, that it is exerted only at insensible distances, which distinguishes it from *gravitation* (see *Attraction*), and between heterogeneous particles, in which it differs from *cohesion*. The properties of the resulting compound differ essentially from its component parts, as a salt is formed by an acid and an alkali. The forms of the elements are often changed, and the change is attended with remarkable phenomena, as the explosion of gunpowder by its conversion into gases, the solidification of water in slaking lime, &c. One of the most important laws of affinity is, that one body has not the same force of affinity towards all others, but attracts them very unequally, and some of them not at all. The knowledge of the affinities of different bodies is of great use to the chemist in effect-

ing decompositions. Bergmann, who first, in 1775, developed the theory of affinities, distinguishes three cases in the reciprocal action of two bodies—when they are both free, which he calls *simple affinity;* when one of them is already in combination, *elective;* and when both are combined in different compounds, *complex*. Berthollet has much improved the theory of affinities. (See *Atomic Theory;* also *Berthollet's Statique Chimique;* and *Berzelius' Theory of Chemical Proportions.*)

Agio is the difference in value between bank money and coin, or other currency. The term is in most frequent use in Holland and Venice. It is, however, used at Hamburg and other places in Germany. It is synonymous with *premium*, when the bank money is worth more than the same nominal amount of the current coin, and with *discount*, when its value is less. The agio at the bank of Amsterdam was from three to four per cent. before the French invasion of Holland in 1795; that of Venice was formally fixed at 20 per cent.; the bank money of each of those places being so much more valuable than the current coin. This difference in value arises often from the circumstance, that the current coin is depreciated by wearing and clipping. The agio of the bank money of Hamburgh was formerly 14 per cent. on this account. Agio is sometimes used to signify the premium or discount on bills of exchange.

Aggregation, in *Physics;* a species of union, whereby several things, which have no natural dependence or connexion with one another, are collected together, so as, in some sense, to constitute one. Thus, a heap of sand, or a mass of ruins, are bodies by aggregation.

Agriculture is the art of cultivating the earth in such a manner as to cause it to produce, in the greatest plenty and perfection, those vegetables which are useful to man, and to the animals which he has subjected to his dominion. This art is the basis of all other arts, and in all countries coeval with the first dawn of civilization. Without agriculture, mankind would be savages, thinly scattered through interminable forests, with no other habitations than caverns, hollow trees or huts, more rude and inconvenient than the most ordinary hovel or cattle-shed of the modern cultivator. It is the most universal as well as the most ancient of the arts, and requires the greatest number of operators. It employs seven-eighths of the population of almost every civilized community.—Agriculture is not only indispensable to national prosperity, but is eminently conducive to the welfare of those who are engaged in it. It gives health to the body, energy to the mind, is favourable to virtuous and temperate habits, and to knowledge and purity of moral character, which are the pillars of good government and the true support of national independence.—With regard to the history of agriculture, we must confine ourselves to slight sketches. The first mention of agriculture is found in the writings of Moses. From them we learn that Cain was a "tiller of the ground," that Abel sacrificed the "firstlings of his flock," and that Noah "began to be a husbandman, and planted a vineyard."

The Chinese, Japanese, Chaldeans, Egyptians, and Phœnicians appear to have held husbandry in high estimation. The Egyptians were so sensible of its blessings, that they ascribed its invention to superhuman agency, and even carried their gratitude to such an absurd excess as to worship the ox, for his services as a labourer. The Carthaginians carried the art of agriculture to a higher degree than other nations, their contemporaries. Mago, one of their most famous generals, wrote no less than twenty-eight books on agricultural topics, which, according to Columella, were translated into Latin by an express decree of the Roman senate.

Hesiod, a Greek writer, supposed to be a contemporary with Homer, wrote a poem on agriculture, entitled *Weeks and Days*, which was so denominated because husbandry requires an exact observance of times and seasons. Other Greek writers wrote on rural economy, and Xenophon among the number, but their works have been lost in the lapse of ages. The implements of Grecian agriculture were very few and simple. Hesiod mentions a plough, consisting of three parts—the share-beam, the draught-pole, and the plough-tail; but antiquarians are not agreed as to its exact form; also a cart with low wheels, and ten spans (seven feet six inches) in width; likewise the rake, sickle, and ox-goad; but no description is given of the mode in which they were constructed. The operations of Grecian culture, according to Hesiod, were neither numerous nor complicated. The ground received three ploughings—one in autumn, another in spring, and a third immediately before sowing the seed. Manures were applied, and Pliny ascribes their invention to the Grecian king Augeas.

Theophrastus mentions six different species of manures, and adds, that a mixture of soil produces the same effect as manures. Clay, he observes, should be mixed with sand, and sand with clay. Seed was sown by hand, and covered with a rake. Grain was reaped with a sickle, bound in sheaves, threshed, then winnowed by wind, laid in chests, bins or granaries, and taken out as wanted by the family, to be pounded in mortars or quern mills into meal.—The ancient Romans venerated the plough, and, in the earliest and purest times of the republic, the greatest praise which could be given to an illustrious character was to say that he was an industrious and judicious husbandman. M. Cato, the censor, who was celebrated as a statesman, orator, and general, having conquered nations and governed provinces, derived his highest and most durable honours from having written a voluminous work on agriculture.

In the Georgics of Virgil, the majesty of verse and the harmony of numbers add dignity and grace to the most useful of all topics. The celebrated Columella flourished in the reign of the emperor Claudius, and wrote twelve books on husbandry, which constituted a complete treatise on rural affairs.

Varro, Pliny, and Palladius were likewise among the distinguished Romans who wrote on agricultural subjects. With regard to the Roman implements of agriculture, we learn that they used a great many, but their particular forms and uses are very imperfectly described. From what we can ascertain respecting them, they appear more worthy of the notice of the curious antiquarian, than of the practical cultivator. The plough is represented by Cato as of two kinds—one for strong, the other for light soils. Varro mentions one with two mould-boards, with which, he says, "when they plough, after sowing the seed, they are said to ridge." Pliny mentions a plough with one mould-board, and others with a coulter, of which he says there were many kinds.—Fallowing was a practice rarely deviated

from by the Romans. In most cases, a fallow and a year's crop succeeded each other. Manure was collected from nearly or quite as many sources as have been resorted to by the moderns. Pigeons' dung was esteemed of the greatest value, and, next to that, a mixture of night soil, scrapings of the streets and urine, which were applied to the roots of the vine and olive. The Romans did not bind their corn into sheaves. When cut, it was sent directly to the area to be threshed, and was separated from the chaff by throwing it from one part of the floor to the other. Feeding down grain, when too luxuriant, was practised. Virgil says, "What commendation shall I give to him, who, lest his corn should lodge, pastures it, while young, as soon as the blade equals the furrow!" Watering on a large scale was applied both to arable and grass lands. Virgil advises to 'bring down the waters of a river upon the sown corn, and, when the field is parched and the plants drying, convey it from the brow of a hill in channels." (*Geor.* l. i, l. 106.)—The farm management most approved of by the scientific husbandmen of Rome was, in general, such as would meet the approbation of modern cultivators. The importance of thorough tillage is illustrated by the following apologue: A vine-dresser had two daughters and a vineyard; when his oldest daughter was married, he gave her a third of his vineyard for a portion, notwithstanding which he had the same quantity of fruit as formerly. When his youngest daughter was married, he gave her half of what remained; still the produce of his vineyard was undiminished. This result was the consequence of his bestowing as much labour on the third part left after his daughters had received their portions, as he had been accustomed to give to the whole vineyard.

The Romans, unlike many conquerors, instead of desolating, improved the countries which they subdued. They seldom or never burned or laid waste conquered countries, but laboured to civilize the inhabitants, and introduce the arts necessary for promoting their comfort and happiness. To facilitate communications from one district or town to another, seems to have been a primary object with them, and their works of this kind are still discernible in numerous places. By employing their troops in this way, when not engaged in active service, their commanders seem to have had greatly the advantage over our modern generals. The Roman soldiers, instead of loitering in camps, or rioting in towns, enervating their strength, and corrupting their morals, were kept regularly at work, on objects highly beneficial to the interests of those whom they subjugated. In the ages of anarchy and barbarism which succeeded the fall of the Roman empire, agriculture was almost wholly abandoned. Pasturage was preferred to tillage, because of the facility with which sheep, oxen, &c. can be driven away or concealed on the approach of an enemy.

The conquest of England by the Normans contributed to the improvement of agriculture in Great Britain. Owing to that event, many thousands of husbandmen, from the fertile and well-cultivated plains of Flanders and Normandy, settled in Great Britain, obtained farms, and employed the same methods in cultivating them, which they had been accustomed to use in their native countries. Some of the Norman barons were great improvers of their lands, and were celebrated in history for their skill in agriculture. The Norman clergy, and especially the monks, did still more in this way than the nobility. The monks of every monastery retained such of their lands as they could most conveniently take charge of, and these they cultivated with great care under their own inspection, and frequently with their own hands. The famous Thomas à Becket, after he was archbishop of Canterbury, used to go out into the field with the monks of the monastery where he happened to reside, and join with them in reaping their corn and making their hay.

The implements of agriculture, at this period, were similar to those in most common use in modern times. The various operations of husbandry, such as manuring, ploughing, sowing, harrowing, reaping, threshing, winnowing, &c., are incidentally mentioned by the writers of those days, but it is impossible to collect from them a definite account of the manner in which those operations were performed. The first English treatise on husbandry was published in the reign of Henry VIII. by Sir A. Fitzherbert, judge of the common pleas. It is entitled the *Book of Husbandry*, and contains directions for draining, clearing, and enclosing a farm, for enriching the soil, and rendering it fit for tillage. Lime, marl, and fallowing, are strongly recommended. "The author of the Book of Husbandry," says Mr. Loudon, "writes from his own experience of more than forty years; and, if we except his biblical allusions, and some vestiges of the superstition of the Roman writers about the influence of the moon, there is very little of his work which should be omitted, and not a great deal that need be added, in so far as respects the culture of corn, in a manual of husbandry adapted to the present time."

Agriculture attained some eminence during the reign of Elizabeth. The principal writers of that period were Tusser, Googe, and Sir Hugh Platt. Tusser's *Five Hundred Points of Husbandry* was published in 1562, and conveys much useful instruction in metre. The treatise of Barnaby Googe, entitled *Whole Art of Husbandry*, was printed in 1558. Sir Hugh Platt's work was entitled *Jewel Houses of Art and Nature*, and was printed in 1594. In the former work, says Loudon, are many valuable hints on the progress of husbandry in the early part of the reign of Elizabeth. Among other curious things, he asserts that the Spanish or Merino sheep was originally derived from England. Several writers on agriculture appeared in England during the commonwealth, whose names, and notices of their works, may be seen in Loudon's *Encyclopædia of Agriculture*.

From the restoration down to the middle of the eighteenth century, agriculture remained almost stationary. Immediately after that period, considerable improvement in the process of culture was introduced by Jethro Tull, a gentleman of Berkshire, who began to drill wheat and other crops about the year 1701, and whose *Horsehoeing Husbandry* was published in 1731. Though this writer's theories were in some respects erroneous, yet even his errors were of service, by exciting inquiry, and calling the attention of husbandmen to important objects. His hostilily to manures, and attempting, in all cases, to substitute additional tillage in their place, were prominent defects in his system. After the time of Tull's publication, no great alteration in British agriculture took place, till Robert Bakewell and others effected some

important improvements in the breed of cattle, sheep, and swine. By skilful selection at first, and constant care afterwards to breed from the best animals. Bakewell at last obtained a variety of sheep, which, for early maturity and the property of returning a great quantity of mutton for the food which they consumed, as well as for the small proportion which the weight of the offal bears to the four quarters, were without precedent. Culley, Cline, Lord Somerville, Sir J. S. Sebright, Darwin, Hunt, Hunter, Young, &c. &c. have all contributed to the improvement of domestic animals, and have left little to be desired in that branch of rural economy.—Among other works on agriculture, of distinguished merit, may be mentioned *The Farmer's Letters, Tour in France, Annals of Agriculture, &c. &c.* by the celebrated Arthur Young; Marshall's numerous and excellent works, commencing with *Minutes of Agriculture*, published in 1787, and ending with his *Review of the Agricultural Reports* in 1816; *Practical Agriculture*, by Dr. R. W. Dickson, &c. &c.

The writings of Kaimes, Anderson, and Sinclair, exhibit a union of philosophical sagacity and patient experiment, which have produced results of great importance to the British nation and to the world. To these we shall only add the name of John Loudon, F. L. S. H. S., whose elaborate *Encyclopædia of Gardening* and *Encyclopædia of Agriculture*, have probably never been surpassed by any similar works in any language.—The establishment of a national board of agriculture was of very great service to British husbandry. Hartlib, a century before, and Lord Kaimes, in his *Gentleman Farmer*, had pointed out the utility of such an institution, but it was left to Sir John Sinclair to carry their ideas into execution. To the indefatigable exertions of that worthy and eminent man the British public are indebted for an institution, whose services cannot be too highly appreciated. "It made farmers, residing in different parts of the kingdom, acquainted with one another, and caused a rapid dissemination of knowledge amongst the whole profession. The art of agriculture was brought into fashion, old practices were amended, new ones introduced, and a degree of exertion called forth heretofore unexampled among agriculturists in this island."—We may now briefly notice the progress of agriculture in the different countries of Europe and America.

French agriculture began to flourish early in the 17th century, under Henry IV., and a work on that subject was published by Olivier de Serres. In 1761, there were 13 agricultural societies in France, and 19 auxiliary societies. Those of Paris, Amiens, and Bordeaux have distinguished themselves by their memoirs. Du Hamel and Buffon made the study of rural economy fashionable, and other writers contributed to the advancement of husbandry. M. de Trudaine introduced the Merino breed of sheep in 1776, and Count Lasteyrie has written a valuable work on sheep-husbandry. The celebrated Arthur Young made an agricultural survey of France in 1787-89. Since that time, several French and English writers have given the statistics of different districts, and the mode of cultivation there in use, and the abbé Rosier and professor Thouin have published general views of the whole kingdom. Bonaparte established many new agricultural societies and professorships, botanical and economical gardens, for the exhibition of different modes of culture, and the dissemination of plants. He also greatly enlarged and enriched that extensive institution, the National Garden, whose professor of culture, the Chevalier Thouin, is one of the most scientific agriculturists in Europe.—The lands in France are not generally enclosed and subdivided by hedges or other fences. Some fences occur near towns, but in general the whole country is open, the boundaries of estates being marked by slight ditches or ridges, with occasional stones or heaps of earth, trees in rows, or thinly scattered. Depredations from passengers on the highways are prevented by *gardes champêtres*, which are established throughout all France. Since the time of Colbert, the French have paid attention to sheep, and there are considerable flocks of Merinos owned by individuals, besides the national flocks. That of Rambouillet, established in 1786, is, or lately was, managed by M. Tessier, an eminent writer on agriculture. Sheep are generally housed, or kept in folds and little yards or enclosures.

Mr. Birkbeck considers the practice of housing or confining sheep as the cause of foot-rot, a disease very common among them in France. Where flocks remain out all night, the shepherd sleeps in a small thatched hut, or portable house, placed on wheels. He guides the flock by walking before them, and his dog guards them from wolves, which still abound in some parts of the country. In the south part of France, the ass and the mule are of frequent use in husbandry. A royal stud of Arabian horses has been kept up at Aurillac, in Limousin, for more than a century, and another has been more recently established near Nismes. Poultry is an important article in French husbandry. Mr. Birkbeck thinks that the consumption of poultry in towns may be equal to that of mutton. The breed of swine is in general bad; but fine hams are made in Bretagne from hogs reared on acorns and fatted with Indian corn. The French implements of agriculture are generally rude and unwieldy, and the operations of husbandry unskilfully performed. The vine is cultivated in France in fields and on terraced hills, in a way different from that which prevails elsewhere. It is planted in hills, like Indian corn, kept low, and managed like a plantation of raspberries. The white mulberry tree is very extensively cultivated for feeding the silk-worm. It is not placed in regular plantations, but in corners, in rows by the sides of roads, &c. The trees are raised from the seed in nurseries, and sold generally, at five years' growth, when they have strong stems. They are planted, staked, and treated as pollards. The eggs of the silk-worm are hatched in rooms heated by means of stoves to 80° of Réaumur ($72\frac{1}{2}$) Fah.) One ounce of eggs requires one hundred weight of leaves, and will produce from 7 to 9 pounds of raw silk. The hatching commences about the end of April, and with the feeding, is over in about a month. Second broods are procured in some places. The silk is wound off the cocoons in little balls by women and children. The olive, the fig, the almond, and various other fruits are also extensively cultivated in France.

Before concluding our view of the agriculture of France, it may be advisable to furnish our readers with M. Dupin's comparative estimate of the above species of labour in that country, viewed in comparison with our own. It is extracted from that excellent work, the *Companion to the Almanack*.

The 31,800,000 inhabitants which now constitute

the population of France, are equivalent to a power of 12,609,057 individuals of the male sex, at the age of full vigour. It is a position generally admitted in France, that two-thirds of the population are employed in agriculture; and that a third only is occupied in manufacturing and commercial pursuits. Hence it results that France possesses

	Effective Labourers.
A human agricultural power equivalent to that of	8,406,038
And a power of industry, manufacturing and commercial, equal to . .	4,203,019
Total	12,609,057

Were it not that the industry of man had found the means of calling extraneous force to its aid, its means would be confined to the amount of power above enumerated; but man employs other forces than his own in agricultural labours, and principally that of the horse, of the ass, of the mule, the ox, and the cow; and with the help of these, the animate agricultural force of France has increased to the following sum:—

Human race .	21,056,667	equivalent to	8,406,038	labouring men.
Horses . . .	1,600,000		11,200,000	
Oxen and cows	6,973,000		17,432,000	
Asses . . .	240,000		240,000	
		Total	37,278,038	

On making similar calculations of the agricultural force of Great Britain, and stating at 15,000,000 the number of inhabitants of England and Scotland, of whom a third only are employed in agriculture, and the other two-thirds in commerce and manufactures, we shall have

Agricultural force	2,132,446	effective working men.
Artisans of all professions .	4,264,893	

If we proceed in the same way with regard to Great Britain, as we have done with respect to France, and make a comparative calculation of the power in men, and the power in other animals engaged in agriculture, we shall find,

Human race. . .	5,000,000	equivalent to	2,132,446	effective labourers.
Horses of full growth	1,250,000		8,750,000	
Oxen, cows, &c. .	5,500,000		13,750,000	
		Total	24,632,446	
		Ireland; approximating Estimate	7,455,701	
		Total for the United Kingdom	32,088,147	

Taking the proportion of this total force of 24,632,446 to the human force applicable to agriculture, we find it to be as 12. Whence it appears that the agriculturists of England and Scotland have discovered the means of creating a force, twelve times the amount of their personal corporeal force, by the use they make of domestic animals; while the additional force, obtained through similar means by the French agriculturists, does not amount to five times their own. It is calculated that in France there are 46,000,000 hectares of land made to yield produce; so that there is an animate power equal to that of 810 labourers for the cultivation of every thousand hectares. The total number of hectares of productive land in Great Britain is 21,643,000; so that there is an animate power equal to that of 1,138 working men for every thousand hectares. The produce of the land in the respective countries, is in proportion to the power employed respectively in its cultivation.

This extract, from the pen of one of the most distinguished political economists in France, will furnish a tolerably accurate view of the comparative effects of British and foreign systems of agriculture, with reference to animate and inanimate force.

Agriculture in Germany. The earliest German writer on husbandry was Conradus Heresbachius, who lived and died in the 16th century. His work, *De Re Rustica*, was an avowed compilation from all the authors who had preceded him. No other books on agriculture, of any note, appeared previous to the 17th century. With regard to the present state of agriculture in Germany, we would remark, that the country is very extensive, and presents a great variety of soils, surface, climate, and culture. Its agricultural produce is for the most part consumed within its limits; but excellent wines are exported from Hungary and the Rhine, together with flax, hams, geese, silk, &c. The culture of the mulberry and the rearing of the silk-worm are carried on as far north as Berlin. The theoretical agriculturists are well acquainted with all the improved implements of Great Britain, and some of them have been introduced, especially in Holstein, Hanover, and Westphalia; but, generally speaking, the ploughs, waggons, &c. are unwieldy and inefficient. Fish are carefully bred and fattened in some places, especially in Prussia, and poultry is every where attended to, particularly in the neighbourhood of Vienna. The culture of forests likewise receives particular attention in that country as well as in France. The common agriculture of Germany is every where improving. Government, as well as individuals, have formed institutions for the instruction of youth in its principles. The Imperial Society of Vienna, the Georgical Institution at Presburg, and that of professor Thaer, in Prussia, may be numbered among recent institutions of this description.

Agriculture in Italy. The climate, soil, and surface of Italy are so various as to have given rise to a greater diversity of culture than is to be found in the whole of Europe besides. Corn, grass, butchers' meat, cheese, butter, rice, silk, cotton, wine, oil, and fruits of all kinds are found in perfection in this fertile country. Loudon asserts that only one-fifth of the surface of Italy is considered sterile, while only a fifth of the surface of France is considered fertile. The population of Italy is greater in proportion to its surface, than that of either France or Great Britain. Among the writers on the rural economy of Italy are, Arthur Young, in 1788, Sismondi, in 1801, and Chateauvieux, in 1812. In Lombardy the lands are generally farmed by *metayers* (from *metà*, half). The landlord pays the taxes and repairs the buildings; the tenant provides cattle, implements, and seeds, and the produce is divided. The irrigation of lands in Lombardy is a remarkable feature of Italian husbandry. All canals taken from rivers are the property of the state, and may be carried through any man's land, provided they do not pass through a garden, or within a certain distance of a mansion, on paying the value of the ground occupied. Water is not only employed for grass-lands (which, when fully watered, are mowed four and sometimes five times a year, and, in some cases, as early as March), but is conducted between the narrow ridges of corn-lands, in the hollows between drilled crops, among vines, or to flood lands, to the depth of a foot or more, which are sown with rice. Water is also used for depositing a surface of mud, in some places where it is charged with that material. The details of

watering, for these and other purposes, are given in various works, and collected in those of Professor Rhe. In general, watered lands let at one-third higher price than those not irrigated. The implements and operations of agriculture in Lombardy are both imperfect. The plough is a rude contrivance, with a handle 13 or 14 feet long. But the cattle are fed with extraordinary care; they are tied up in stalls, bled once or twice, cleaned and rubbed with oil, afterwards combed and brushed twice a day. Their food in summer is clover or other green herbage; in winter, a mixture of elm-leaves, clover-hay, and pulverized walnut-cake, over which boiling water is poured, and bran and salt added. In a short time the cattle cast their hair, grow smooth, round, and fat, and so improved as to double their value to the butcher. The tomato or love-apple (*solanum lycopersicum*), so extensively used in Italian cookery, forms an article of field-culture near Pompeii, and especially in Sicily, from whence it is sent to Naples, Rome, and several towns on the Mediterranean sea.

Agriculture of the United States of America. The territory of the United States is very extensive, and presents almost every variety of soil and climate. The agriculture of this wide-spread country embraces all the products of European cultivation, together with some (such as sugar and indigo) which are rarely made objects of tillage in any part of Europe. A full description of the agriculture of these states would require a large volume. We shall confine ourselves to such sketches as we may deem of most practical importance to those who are or intend to become cultivators of North American soil. The farms of the Eastern, Northern, and Middle States consist generally of from 50 to 200 acres, seldom rising to more than 300, and frequently falling short of 200 acres. These farms are enclosed, and divided either by stone walls, or rail fences made of timber, hedges not being common. The building first erected on a "new lot," or on a tract of land not yet cleared from its native growth of timber, is what is called a log-house. This is a hut or cabin made of round, straight logs, about a foot in diameter, lying on each other, and notched in at the corners. The intervals between the logs are filled with slips of wood, and the crevices generally stopped with mortar made of clay. The fire-place commonly consists of rough stones, so placed as to form a hearth, on which wood may be burned. Sometimes these stones are made to assume the form of a chimney, and are carried up through the roof; and sometimes a hole in the roof is the only substitute for a chimney. The roof is made of rafters, forming an acute angle at the summit of the erection, and is covered with shingles, commonly split from pine-trees, or with bark peeled from the hemlock (*pinus canadensis*).—When the occupant or "first settler" of this "new land" finds himself in "comfortable circumstances," he builds what is styled a frame-house, composed of timber held together by tenons, mortises, and pins, and boarded, shingled, and clap-boarded on the outside, and often painted white, sometimes red. Houses of this kind generally contain a dining-room and kitchen, and three or four bed-rooms on the same floor. They are rarely destitute of good cellars, which the nature of the climate renders almost indispensable. The farm-buildings consist of a barn, proportioned to the size of the farm, with stalls for horses and cows on each side, and a threshing-floor in the middle; and the more wealthy farmers add a cellar under the barn, a part of which receives the manure from the stalls, and another part serves as a store-room for roots, &c. for feeding stock. What is called a corn-barn is likewise very common, which is built exclusively for storing the ears of Indian corn. The sleepers of this building are generally set up four or five feet from the ground, on smooth stone posts or pillars, which rats, mice, or other vermin cannot ascend. With regard to the best manner of clearing forest-land from its natural growth of timber, the following observations may be of use to a "first settler." In those parts of the country where wood is of but little value, the trees are felled in one of the summer months, the earlier in the season the better, as the stumps will be less apt to sprout, and the trees will have a longer time to dry. The trees lie till the following spring, when such limbs as are not very near the ground should be cut off that they may burn the better. Fire must be put to them in the driest part of the month of May, or, if the whole of that month prove wet, it may be applied in the beginning of June. Only the bodies of the trees will remain after burning, and some of them will be burned into pieces. Those which require to be made shorter are cut in pieces nearly of a length, drawn together by oxen, piled in close heaps, and burned; such trees and logs being reserved as may be needful for fencing the *lot*. The heating of the soil so destroys the green roots, and the ashes made by the burning are so beneficial as manure to the land, that it will produce a good crop of wheat or Indian corn without ploughing, hoeing, or manuring. If new land lie in such a situation that its natural growth may turn to better account, whether for timber or fire-wood, it will be an unpardonable waste to burn the wood on the ground. But if the trees be taken off, the land must be ploughed after clearing, or it will not produce a crop of any kind.

We shall conclude with a few brief notices of some of the most prominent benefits and improvements which modern science has contributed to the art of agriculture. The husbandmen of antiquity, as well as those of the middle ages, were destitute of many advantages enjoyed by the modern cultivator. Neither the practical nor the theoretical agriculturists of those periods had any correct knowledge of geology, mineralogy, chemistry, botany, vegetable physiology, or natural philosophy; but these sciences have given the modern husbandman the command of important agents, elements and principles, of which the ancients had no idea. The precepts of their writers were conformable to their experience; but the *rationale* of the practices they prescribed they could not, and rarely attempted, to explain. Nature's most simple modes of operation were to them inexplicable, and their ignorance of causes often led to erroneous calculations with regard to effects. We are indebted to modern science for the following, among other improvements: viz. 1. A correct knowledge of the nature and properties of manures, mineral, animal, and vegetable; the best modes of applying them; and the particular crops for which particular sorts of manures are best suited. 2. The method of using all manures of animal and vegetable origin while fresh, before the sun, air, and rain, or other moisture, has robbed them of their most valuable properties. It was formerly the practice to place barn-yard manure in layers or masses for the purpose of rotting, and turn

it over frequently with the plough or spade, till the whole had become a mere *caput mortuum*, destitute of almost all its original fertilizing substances, and deteriorated in quality almost as much as it was reduced in quantity. 3. The knowledge and means of chemically analyzing soils, by which we can ascertain their constituent parts, and thus learn what substances are wanted to increase their fertility. 4. The introduction of the root-husbandry, or the raising of potatoes, turnips, mangel-wurzel, &c. extensively, by field-husbandry, for feeding cattle, by which a given quantity of land may be made to produce much more nutritive matter than if it were occupied by grain or grass crops, and the health as well as the thriving of the animals in the winter season greatly promoted. 5. Laying down lands to grass, either for pasture or mowing, with a greater variety of grasses, and with kinds adapted to a greater variety of soils; such as orchard-grass (*dactylis glomerata*), for dry land, foul meadow-grass (*agrostis stricta*), for very wet land; herds'-grass or timothy (*phleum pratense*), for stiff, clayey soils, &c. &c. 6. The substitution of fallow crops (or such crops as require cultivation and stirring of the ground while the plants are growing) in the place of naked fallows, in which the land is allowed to remain without yielding any profitable product, in order to renew its fertility. Fields may be so foul with weeds, as to require a fallow, but not what is too often understood by that term in this country. "In England, when a farmer is compelled to fallow a field, he lets the weeds grow into blossom, and then turns them down; in America, a fallow means a field where the produce is a crop of weeds running to seed, instead of a crop of grain." 7. The art of breeding the best animals and the best vegetables, by a judicious selection of individuals to propagate from. —These improvements, with others too numerous to be here specified, have rendered the agriculture of the present period very different from that of the middle ages, when it had sunk far below the degree of perfection which it had reached among the Romans.

The practice of agriculture will be found fully discussed and illustrated under the articles, Plough, Harrow, Threshing Machine, &c.

Ague, in *Medicine;* a disorder belonging to the class of intermittent fevers (*febres intermittentes*). It may be followed by serious consequences, but generally it is more troublesome than dangerous, and is sometimes even considered salutary. According to the length of the *apyrexia*, or intermission between one febrile paroxysm and another, agues are denominated *quotidians, tertians,* or *quartans;* which latter are much the more obstinate, being generally attended with a greater degree of visceral obstruction than those the attacks of which return at shorter intervals. The quartan ague is apt to terminate in dropsy. An ague paroxysm has been divided into the cold, the hot, and the sweating stages. The feeling of extreme cold, in the first stage, cannot be prevented by fire or the heat of summer. Generally after the sweating stage, in which there is a profuse exhalation from the pores of the skin, with a flow of urine depositing a copious sediment of a lateritious or brick-dust appearance, the patient falls into a refreshing sleep, from which he awakes without any remains of indisposition, except a slight degree of languor and debility. Agues occur chiefly in situations where there are shallow stagnant waters. Hence their frequency in Holland, in the East and West Indies, in the flat, marshy parts of England, and the thinly-settled parts of the United States, where they diminish with the clearing of the woods and the draining of the lands. The neighbourhood of rivers or marshes, therefore, is carefully to be avoided by persons afflicted with agues. They are cured by medicines, which, at the same time that they exert a tonic influence, produce and keep up an impression upon the system greater than that communicated by the causes of the disease; such as Peruvian bark, various bitter and astringent drugs, certain metallic salts, &c.

Ague-cake; a name sometimes given to a hard tumour on the left side of the belly, lower than the false ribs, said to be the effect of intermittent fever.

Air. The air, or atmosphere in which we live and breathe, is a thin, invisible, and elastic fluid. It is material, and as such must possess weight, and act with a certain determinate pressure on all those bodies which are immersed in it. In the present article we purpose examining the general mechanical characteristics of our atmosphere, leaving its chemical nature to be discussed under that head. The various amusing and instructive experiments connected with the air-pump, will be found in the treatise on Pneumatics, in the alphabetical arrangement.

Various conjectures have been formed with respect to the height of the atmosphere; and as we know to a certainty the relative weight of a column of the atmosphere by the height to which its pressure will raise water or mercury in an empty tube, so different calculations have been founded on these data, to ascertain its extent as well as its density at different heights. If the air of our atmosphere were indeed every where of a uniform density, the problem would be very easily solved. We should in that case have nothing more to do than to find out the proportions between the height of a short pillar of air, and a small pillar of water of equal weight; and having compared the proportion which the height these bear to each other in the small, the same proportions would be certain to hold good in the great, between a pillar of water thirty-two feet high, and a pillar of air that reaches to the top of the atmosphere, the height of which we wish to know. Thus, for instance, we find a certain weight of water reaches one inch high, and a similar weight of air reaches seventy-two feet high: this then is the proportion two such pillars bear to each other on the small scale. Now, if one inch of water is equal to seventy-two feet of air, to how much air will thirty-two feet of water be equal; by the common rule of proportion we readily find, that thirty-two feet, or 384 inches, of water will be equal to 331.776 inches, which makes something more than five miles, which would be the height of the atmosphere, was its density every where the same as at the earth, where seventy-two feet of air were equal to one inch of water. But this is not really the case; for the air's density is not every where the same, but decreases as the pressure upon it decreases; so that the air becomes lighter and lighter the higher we ascend; and at the upper part of the atmosphere, where the pressure is scarcely any thing at all, the air, dilating in proportion, must be expanded to a very great extent; and therefore the height of the atmosphere must be much greater than has appeared by the last calculation, in which its density was supposed to be every where as great as at the surface of the earth. In order, therefore, to determine the height of the atmosphere more exactly, geometricians have

endeavoured to determine the density of the air at different distances from the earth.

The following sketch will give an idea of the method which some have taken to determine this density, which is preparatory to finding out the weight of the atmosphere more exactly. If we suppose a pillar of air to reach from the top of the atmosphere down to the earth's surface, and imagine it marked like a standard by inches, from the top to the bottom, and still further suppose that each inch of air, if not at all compressed, will weigh one grain, the topmost inch then weighs one grain, as it suffers no compression whatever; the second inch is pressed by the topmost with a weight of one grain, and this, added to its own natural weight or density of one grain, now makes its density, which is ever equal to the pressure, two grains. The third inch by the weight of the two inches above it, whose weight united make three grains, and these added to its natural weight give it a density of four grains. The fourth inch is pressed by the united weight of the three above it, which together make seven grains, and this added to its natural weight gives it a density of eight grains. The fifth inch being pressed by all the former fifteen, and its own weight added, gives it a density of sixteen grains, and so on descending downwards to the bottom. The first inch has a density of one, the second inch a density of two, the third inch a density of four, the fourth of eight, the fifth of sixteen, and so on. Thus the inches of air increase in density as they descend from the top, at the rate of 1, 2, 4, 8, 16, 32, 64, &c. Or if we reverse this, and begin at the bottom, we may say, that the density of each of these inches grows less upwards. If, instead of inches, we suppose the parts into which this pillar of air is divided to be extremely small, and like those of air, the rule will hold equally good in both. So that we may generally assert that the density of the air from the surface of the earth decreases in a geometrical proportion.

This being understood, should we now desire to know the density of the air at any certain height, we have only first to find out how much the density of the air is diminished to a certain standard height, and thence proceed to tell how much it will be diminished at the greatest heights that can be imagined. At small heights the diminution of its density is by fractional or broken numbers. We will suppose at once that at the height of five miles the air is twice less dense than at the surface of the earth: at two leagues high it must be four times thinner and lighter, and at three leagues eight times thinner and less dense, and so on. In short, whatever decrease it received in the first step, it will continue to have in the same proportion in the second, third, and so on; and this, as was observed, is called geometrical progression.

In proof of the great diminution in the elasticity of the air as we ascend from the earth's surface, it may be enough to state that if the common balloon was filled on ascending from the earth, the gas would burst its "silken envelope" long ere it had attained the ordinary elevation of those flying vehicles. One of the modes of ascertaining by direct experiment the diminished density, consists in filling a flask with air at a given altitude, and then closing the aperture till the experimentor arrives at the earth's surface. The aperture is afterwards opened under water, and the difference between the air above and below is indicated by the quantity of water which enters.

Dr. Cotes has also shewn, that if altitudes in the air be taken in arithmetical proportion, the rarity of the air will be in geometrical proportion. For instance,

At the altitude of … Miles above the surface of the earth, the air is	… times thinner and lighter than at the earth's surface.
7	4
14	16
21	64
28	256
35	1024
42	4096
49	16384
56	65536
63	262144
70	1048576
77	4194304
84	16777216
91	67108864
98	268435456
105	1073741824
112	4294967296
119	17179869184
126	68719476736
133	274877906944
140	1099511627776

And hence it is easy to prove by calculation, that a cubic inch of such air as we breathe, would be so much rarefied at the altitude of 500 miles, that it would fill a sphere equal in diameter to the orbit of Saturn.

Upon the same principle it was attempted to calculate the height of the atmosphere, by carrying a barometer to the top of a high mountain, and the density of the air at two or three different stations was easily ascertained. But so feeble are human efforts in endeavouring to comprehend and measure the works of the Creator, that this theory was soon demolished. It was found that the barometrical observations by no means corresponded with the density which, by other experiments, the air ought to have had; and it was therefore suspected that the upper parts of the atmosphere were not subject to the same laws or the same proportions as those which were nearer the surface of the earth. Another still more ingenious method was therefore devised. Astronomers know to the greatest exactness the part of the heavens in which the sun is at any one moment of time: they know, for instance, the moment at which it will set, and also the precise time at which it will rise. They soon, however, found that the light of the sun was visible before its body, and that the sun itself appeared some minutes sooner above the horizon than it ought to have done from their calculations. Twilight is seen long before the sun appears, and that at a time when it is several degrees lower than the horizon. There is then, in this case, something which deceives our sight; for we cannot suppose the sun to be so irregular in its motions as to vary every morning; for this would disturb the regularity of nature. The deception actually exists in the atmosphere: by looking through this dense, transparent substance, every celestial object that lies beyond it is seemingly raised up, in a way similar to the appearance of a piece of money in a basin filled with water. Hence it is plain, that if the atmosphere was away, the sun's light would not be brought to view so long in the morning before the sun itself actually appears. The sun itself without the atmosphere would appear one entire blaze of light the instant it rose, and leave us in total darkness the moment of its setting. The length of the twilight, therefore, is in proportion to the height of the atmosphere: or let us invert this, and say that the height of the atmosphere is in proportion to the length of the twilight: it is generally found, by this means, to be about forty-five miles high, so that it was hence concluded either that that was the actual limit of the

atmostphere, or that it must be of an extreme rarity at that height.

Dr. Arnot, in his *Treatise on Physics*, gives a very beautiful and familiar view of the effects of atmospheric pressure in changing the temperature at various altitudes. The following is his explanation of the phenomenon. If a gallon of air at the surface of the earth contain a certain quantity of heat, this must be diffused equally through the space of the gallon; but if the air be then compressed into one-tenth of the bulk, there will be ten times as much heat in that tenth as there was before; and the increase will affect the thermometer. In like manner, if by taking off pressure the gallon be made to dilate to ten gallons, the heat will be in the same proportion diffused, and any one part will be proportionably colder than before. It is known that air may be so much compressed under the piston of a close syringe, that the heat in it similary concentrated, becomes intense enough to inflame tinder attached to the bottom of the piston. This contrivance is in common use as a means of obtaining an instantaneous light, and is called the match syringe.

Now, for the reason here explained, the air near the surface of the earth, forming the bottom of the atmosphere, because condensed by the weight of the air above it, is much warmer than if it were suddenly carried higher up, where, from the pressure being less, it would be more expanded or thin. In many cases the height of mountains may be estimated by the difference of temperature observed at the bottom and at the top. While a thermometer stands at 60° at the bottom of St. Paul's Cathedral, in London, another marks only 58° at the top of the dome; and in the lofty ascent of a balloon, the thermometer soon falls to the freezing point, and below it, so that to the aeronaut the cold becomes almost insupportable.

In every part of the earth there is a certain elevation in the atmosphere, different according to the proximity to the equator, at which the thermometer never rises above the freezing point,—and this limit is called the level of perpetual congelation. In Norway, it is at five thousand feet above the level of the sea; in Switzerland, at six thousand five hundred; in Spain and Italy, at seven thousand; farther south, at Teneriffe, at nine thousand; directly under the sun, as in Central Africa, and among the Andes, in America, it is about fourteen thousand.

It appears, therefore, that the same low temperature may be met with at the equator as at the poles, by rising to find it; and we see why the snow-capt mountains are not the tenants only of high northern and southern latitudes. It is this truth which renders many parts of the tropical regions of the earth not only tolerable abodes, but as suitable as any on earth; although the ancient philosophers of Europe thought them, by reason of the great heat, uninhabitable by man, and an everlasting barrier between the northern and southern hemispheres. Much of the central land of America near the tropics is so raised, that as to agreeable temperature it rivals, an European climate, while the lightness and purity of air, and the brightness of the sun, add delightfully to its charms.

The vast expanse of table-land forming the empire of Mexico is of this kind, enjoying the immediate proximity of the sun, and yet, by its elevation of seven thousand feet above the level of the ocean, possessing the most healthful freshness The land in many parts has the fertility of a cultivated garden, and can produce naturally most of the treasures of vegetation found scattered over the diversified face of the earth. Mexico, well governed, might become a realization of paradise. The plains of Columbia, in South America, and indeed all along the ridge of the Andes, are similarly circumstanced. What a singular contrast it is, after sailing one thousand miles up the level river Magdalena, in a heat scarcely equalled on the plains of India, all at once to climb from the low region to the table-land above, where Santa Fé de Bogota, the capital of the republic, is seen smiling over interminable plains, that bear the livery of the fairest fields of Europe.

Persons not reflecting on the law which we are now illustrating, have expressed surprise that wind or air blowing down upon them from a snow-clad mountain should still be warm and temperate. The truth is, that there is just as much heat combined with an ounce of air on the mountain top as in the valley; but above, the heat is diffused through a space perhaps twice as great as when below, and therefore is less sensible. It may be the same air which sweeps over a warm plain at the side of a mountain, which then rises and freezes water on the summit, and which in an hour after, or less, is again found among the flowers of another valley, as a gentle and warm breeze.

As the temperature in different parts of the atmosphere depends thus upon the rarity of the air, and therefore upon the height, the vegetable productions of each distinct region or elevation have a distinct character; while many other peculiarities of places and climate depend on the rarity of the air.

The animal body is made up of solids and fluids, and the atmospheric pressure affects it accordingly. One has difficulty at first in believing that a man's body should be bearing a pressure of fifteen pounds on every square inch of its surface, while he remains altogether insensible to the influence; but such is the fact. Reflection discovers that his not feeling the fluid pressure, is owing to its being perfectly uniform all around. If a pressure of the same kind be even many times greater, such, for instance, as fishes bear in deep water, or as a man supports in the diving-bell, it must equally pass unnoticed. Fishes are at their ease in a depth of water where the pressure around will instantly break or burst inwards almost the strongest empty vessel that can be sent down; and men walk on earth without discovering a heavy atmosphere about them, which, however, will instantly crush together the sides of a thick iron boiler, left for a moment without the counteracting internal support of steam or air.

The fluid pressure on animal bodies, thus unperceived under ordinary circumstances, may be rendered instantly sensible by a little artificial arrangement. In water, for instance, an open tube partially immersed, becomes full to the level of the water around it, and the water contained in it is supported by what is immediately below its mouth: now, a flat fish resting closely against the mouth of the tube, would evidently be bearing on its back the whole of this weight—perhaps 100 pounds; but the fish would not thereby be pushed away, nor would it even feel its burden, because the upward pressure of the water immediately under it would just counterbalance, while the lateral pressure around would prevent any crushing effect of the mere upward and downward

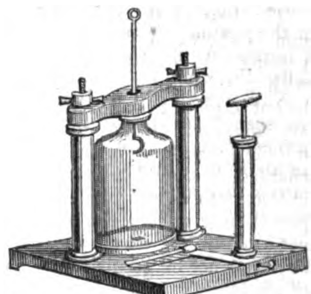
forces. But if, while the fish continued in the supposed situation, the 100 pounds of water were lifted from off its back by a piston in the tube, the opposite upward pressure of 100 pounds would at once crush its body into the tube, and destroy it. At a less depth, or with a smaller tube, the effect might not be fatal, but there would be a bulging or swelling of the substance of the fish into the mouth of the tube. In air, and in the human body, a perfectly analogous case is exhibited. A man without pain or peculiar sensation, lays his hand closely on the mouth of a vessel containing air, but the instant that the air is withdrawn from within the vessel, the then unresisted pressure of the air on the outside fixes the hand upon the vessel's mouth, causes the flesh to swell or bulge into it, and makes the blood ooze from any crack or puncture in the skin.

These last few lines closely describe the surgical operation of cupping; the essential circumstances of which are the application of a cup or glass with a smooth, blunt lip, to the skin of any part, and the extraction, by a syringe or other means, of a portion of the air from within the cup. It may facilitate to some minds the exact comprehension of this phenomenon, to consider the similar case of a small bladder or bag of india-rubber full of any fluid, and pressed between the hands on every part of its surface except one, at which part it swells, and even bursts if the pressure be strong enough. So in cupping, medicinally, the whole body, except the surface under the cup, is squeezed with a force of fifteen pounds on the square inch, while in that one situation the pressure is diminished according to the degree of exhaustion in the cup, and the blood consequently accumulates there. The mere application of a cup with exhaustion, constitutes the operation called dry-cupping: to obtain blood, the cup is removed, and the affected part is cut into by the simultaneous stroke of a number of lancet points. The cup is afterwards applied as before, so that the blood may rush forth under the diminished pressure. The partial vacuum in the cup may be produced either by the action of a syringe, or by burning a little spirit in the cup, and applying it while the momentary dilitation effected by the heat has driven out the greater part of the air. The human mouth applied upon a part, becomes a small cupping machine, and formerly, in cases of poisoned wounds, was used as such. It may be proper to add, that the late discoveries of Dr. Barry have shown that the timely application of a cupping-glass prevents the spread of contagion either in cases of poison or hydrophobia.

If a flat piece of moist leather be put in close contact with a heavy body, as a stone, it will be found to adhere to it with considerable force; and if a cord of sufficient length be attached to the centre of the leather, the stone may be raised by the cord. This effect arises from the exclusion of the air between the leather and the stone. The weight of the atmosphere presses their surfaces together with a force amounting to 15 pounds on every square inch of those surfaces in contact. If the weight of the stone be less than the number of pounds which would be expressed by multiplying the number of square inches in the surfaces of contact by 15, then the stone may be raised by the leather; but if the stone exceed this weight, it will not suffer itself to be elevated by these means.

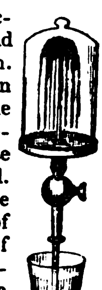
The power of flies and other insects to walk on ceilings and surfaces presented downwards, or upon smooth panes of glass in an upright position, is said to depend on the formation of their feet. This is such, that they act in the manner above described, respecting the leather attached to a stone; the feet, in fact, act as suckers, excluding the air between them and the surface with which they are in contact, and the atmospheric pressure keeps the animal in its position. In the same manner the hydrostatic pressure attaches fishes to rocks; and that "giant of the deep," the walrus, supports itself by a sort of air-pump apparatus in its feet.

Air-Bed. This is a very ingenious substitute for the ordinary feather bed. Mr. Macintosh, the patentee, employs the same elastic material in the formation of pillows for invalids. The envelope or bag which contains the air, consists of a stratum of india-rubber between two sheets of strong cotton, and a small tube is attached, to which the lips may be applied to inflate the case for use.



Air-Condenser. This is a very necessary accompaniment to the air-pump, which will presently be described. Air is compressible, and its elasticity may be beautifully illustrated in the accompanying little apparatus. It consists of a flat table, supporting a brass plate and glass receiver. The columns rising from the table serve, by the aid of a cross-bar and screws, to hold the receiver down to the plate, and prevent the escape of air. The upright syringe, with its piston and handle, is used to inject air into the receiver. Each time the piston is depressed, as much air is forced in as is equal to the internal dimensions of the tube. The wire and hook which are seen in the centre of the receiver, serves to communicate with the interior during the performance of experiments. There is a gauge at one side to show the amount of condensation.

Air-Fountain. There are two species of fountains which may be classed under this head. The most simple arrangement consists in employing the elastic force of the air compressed in a close vessel, and made to act on the surface of the water as in the pump.



The second form is exhibited in the accompanying wood-cut, and requires the aid of the air-pump to put it in operation. The receiver in which the fountain is seen to play must be made to fit air-tight on the ground brass plate beneath. The stop-cock must then be screwed into the plate of the air-pump, and a vacuum formed. After turning the stop-cock to prevent the entrance of the air, the lower extremity of the tube should be immersed in a vessel of water, and on again opening the communication the water will be seen to rise in a continuous stream, forming a beautiful *jet d'eaux*. The elevation of the water in this case is, it will be obvious, dependant on the pressure of the atmosphere, which has already been fully illustrated.

AIR GUN. This instrument owes its power to the expansive force of condensed air. We have in the previous article shown that air is highly elastic, and that it may be compressed by a common syringe.

The ball attached to the gun is intended as a reservoir for the air, and a portion of this is allowed to escape each time the trigger is drawn, so that it presses against the bullet precisely in the same way as common gunpowder.

The first account we meet with of an air-gun is in the *Elémens d'Artillerie* of David Rivaut, who was preceptor to Louis XIII. of France. He ascribes the invention to Marin of Lisseau, who presented one to Henry IV. Instruments of this kind were, however, not wholly unknown to the ancients.

The best of the modern forms of the gun is shown in the accompanying engraving. It consists of a common barrel with a spherical reservoir. It may not be out of place to add a word of cautionary advice with regard to the use of this missile apparatus. When the gun is fully charged, it should on no account be left in that state, as many balls will for a short period bear an amount of force which they would not do for any length of time. There is another circumstance of peculiar moment, namely, the effect of an increased temperature on the ball, as a slight change in the heat of the enclosed air will very materially affect the elastic force, and this circumstance has frequently been productive of explosion.

The elasticity of highly-condensed air has been estimated by Mr. Robins as equal to about one thousand times that of common air; admitting that therefore to be correct (although there seems to be great reason to suppose it much underrated), it would be necessary that air should be condensed one thousand times more than its natural state, to produce the same effect as gunpowder. There is, however, an important consideration to be attended to, viz. that the velocities with which equal balls are impelled, are directly proportional to the square-roots of the forces; so that if the air in the air-gun be condensed only ten times, the velocity with which it will project a ball will be one-tenth of that arising from gunpowder; and if the air were condensed twenty times, it would communicate a velocity equal to that of one-seventh of that of gunpowder, and so on.

Air-guns, however, project their balls with a much greater proportionate velocity than that stated above, and for this reason, that as the reservoir or magazine of condensed air is commonly very large, in proportion to the tube which contains the ball, its density is very little altered by expanding through that narrow tube, and consequently the ball is urged all the way by nearly the same uniform force as at the first instant; whereas, the elastic fluid arising from inflamed gunpowder is but very small in proportion to the tube or barrel of the gun, occupying, indeed, but a very small portion of it next the butt-end, and, therefore, by dilating into a comparatively large space as it urges the ball along the barrel, its elastic force is proportionally weakened, and it acts always less and less on the ball in the tube; whence it happens, that air condensed into a pretty large machine only ten times, will project its ball with a velocity but little inferior to that given by gunpowder; but if the valve of communication be suddenly shut again by a spring, after opening to admit some air, it will be requisite to have the condensing syringe of small bore, perhaps not more than half an inch in diameter; otherwise the force requisite to produce the compression will become so great, that the operator cannot work the machine; for, as the pressure against every square inch is about 15 lbs., and against every circular area of an inch in diameter 12 lbs., if the syringe be an inch in diameter, it will require a force of as many times 12 lbs. as the density of the air in the receiver exceeds that of the common atmosphere: so that, when the condensation is ten times, the force required will be 120 lbs.; whereas, with a half-inch bore, it will only amount to 30 lbs.

AIR-PUMP. Most of the important facts which have been presented to the notice of the reader under our article AIR, may be said to have been elicited by the employment of this instrument. Prior to the invention of the air-pump, the mechanical properties of the atmosphere were known only by a few isolated natural phenomena, and even the early air-pump was little more than an amusing toy, but in the present day it has become a valuable pneumatic machine.

In 1654, Otto de Geuricke, a counsellor at Hamburgh, and a very ingenious man, invented a method of exhausting a vessel of air by means of a syringe; and this was the first kind of air-pump made use of. He publicly exhibited a great many experiments made with it, before the Emperor of Germany at Ratisbon, which immediately attracted the attention of the philosophical world. An account of these was published by Scottus, professor of mathematics at Wirtembergh. The instrument was, however, still very awkward and imperfect. In order to try experiments with it, they were obliged to place part of the apparatus under water to keep it air-tight.

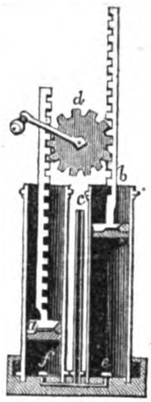
The celebrated Robert Boyle, upon hearing what Guericke had done, but without seeing any description of the apparatus, contrived an instrument for the same purpose; and his instrument, which was a single piston worked by a pinion and rack, may be considered as the origin of the present air-pump. The experiments which he made with it were both numerous and important; and he acquired such fame by them, that the exhausted vessel was called the Boylean vacuum.

Dr. Hook, a very ingenious mechanic, as we shall presently show, greatly improved this machine, by giving it two barrels and pistons. This removed a great inconvenience in the pumps with a single barrel, the pistons of which had to support the whole weight of the atmosphere, and therefore required a great force to work them. But by having two pistons, the pressure upon one is made to counterbalance that on the other, and the experimentor is thus enabled to work the instrument with the greatest ease.

He also invented the gauge, or instrument for measuring the degree of rarefaction, or exhaustion, produced in the receiver, which is a necessary appendage to the air-pump. If a barometer be included beneath the receiver, the mercury will stand at the same height as the open air, but when the receiver begins to be exhausted, the mercury will descend,

and rest at a height which is, in its proportion to the former height, as the spring of the air remaining in the receiver is to its spring before exhaustion.

The only air-pump which it may be advisable to describe in the present place, is that which is commonly employed for pneumatic purposes. It is shown in the accompanying diagram, and consists of two barrels furnished with pistons fitting air-tight.



Each of the barrels has a small aperture and valve communicating with the general orifice *c*, under the receiver of the pump. When the first piston *b* is raised, a vacuum is formed beneath, and a portion of air entering from the receiver by the valve *e* occupies the barrel.

On reversing the direction of the handle and wheel, the rack which had been raised is depressed, and the air escapes through a similar valve in the piston. Thus by the alternate elevation and depression of the racks, *a* and *b*, the rarefaction is carried on in both barrels, though a perfect vacuum can never be obtained.

The air-pumps most commonly used are made either with brass stop-cocks, or with valves of oil-skin or of leather, for preventing the return of the air into the receiver, out of which it had been exhausted. Pumps with stop-cocks, when well made, and newly put together, are generally found to rarify the air to a greater degree than those which are made with valves; but after having been used for some time, they become less accurate than those with valves. But the valves are also imperfect; as the external air, pressing upon that in the piston, prevents its rising, when the elastic force of the air in the receiver under exhaustion is much diminished. Attempts have been made, particularly by the Abbé Nollet and M. Gravesande, to perfect the construction of cocks. In Gravesande's double-barrelled pump, the cocks at the bottom of the pistons are turned by an apparatus that is moved by the handle of the pump: the piston has no valve, and the rod is connected with it by a stirrup, as in a common pump. This rod has a cylindrical part, which passes through a stirrup, and moves tightly in it through the space of about half an inch, between a shoulder above and a nut below. The stirrup supports a round plate, which has a short square tube, that fits tight into the hole of a piece of cork, and which has also a square shank that goes into the square tube. Between the plate and the cork is put a piece of thin leather, soaked in oil, and another is placed between the cork and the plate which forms the sole of the stirrup. When the winch is turned to raise the piston from the bottom of the barrel, the friction of the piston against the barrel keeps it in its place, and the rod is drawn up through the stirrup. The wheel has thus liberty to turn about an inch; and this is sufficient to turn the cock, so as to cut off the communication with the external air, and to open that with the receiver.

When this is done, the continued motion serves to raise up the piston to the top of the barrel. When the winch is turned in the opposite direction, the piston remains fixed till the cock is turned, so as to shut the communication with the receiver and open that with the external air. The cock has one perforation in the direction of its axis, and another perpendicular to it; and after reaching the centre, it passes along the axis of the cock, and communicates with the open air. By opening the above communication, the air rushes in and balances the pressure on the upper side of the piston in this barrel, so that the pressure on the other must be counteracted by the person who works the pump. In order to obviate this inconvenience, Gravesande put a valve on the orifice of the cock, by tying over it a slip of wet bladder or oiled leather; and by means of this the piston is pressed down, as long as the air in the barrel is more rarified than the outward air, just as if the valve was in the piston itself. Gravesande, and also Muschenbrock, extol the operation of this pump, as exceeding that of pumps with valves. But it is evident that no precise estimate of its performance can be obtained, whilst the pistons, valves, and leathers of the pump are prepared by steeping them in oil, and afterwards in a mixture of water and spirits of wine. With this preparation the gauge could not be brought within one-fifth of an inch of the barometer. Besides, a considerable space is left between the piston and cock, from which the air is never expelled; and if this be made very small, the pump must be worked very slowly, otherwise the air will not have time to diffuse itself from the receiver into the barrel; especially when the expelling force, or the elasticity of the air, towards the close of the operation, is very small. The rarefaction will likewise be retarded by the valve, which will not open till the air below the piston is considerably denser than the external air. The cocks in pumps of this kind are subject to become loose by use, and to admit air; an inconvenience which might, indeed, be prevented by placing the barrels in a vessel filled with oil. Those of our readers who wish for further information relative to Gravesande's pump, may find it with a figure in Gravesande's *Mathem. Elem. of Natural Philosophy*, by Desagulier, vol. ii. p. 14, &c. These pumps are now almost superseded by the cheaper and more simple contrivance of the valves, formed by tying a strip of bladder over a small hole, through which the air is allowed to pass in one direction only.

In the year 1750, the ingenious Mr. Smeaton directed his attention to the improvement of valve pumps. In considering the structure of these pumps, he observed that the principal causes of their imperfection might be traced to the difficulty of opening the valves at the bottom of the barrels, and the want of accuracy in the fitting of the piston when put down to the bottom. The first of these imperfections is owing to the smallness of the common valves, which are made of a piece of thin bladder stretched over a hole generally much less than one-tenth of an inch in diameter, and to the adhesion of the bladder to the plate upon which it is spread by reason of the oil or water with which it is moistened: as the rarefaction of the air in the receiver is continued, its spring, as we have already stated, becomes so weak that it is unable to overcome the cohesion of the bladder to the plate, the weight of the bladder, and the resistance occasioned by its being stretched. The larger the hole is, over which the bladder is laid, a proportionably greater force is exerted upon it by the included air in order to lift it up; and yet the aperture of the hole cannot be made very large, because the pressure of the incumbent air would either

burst the valve, or so far force it down into the cavity as to prevent its lying flat and close upon the plate. In order to avoid these inconveniencies, instead of one hole, Mr. Smeaton makes use of seven, all of equal size and shape, one being in the centre, and the other six round it, so that the valve is supported at proper distances by a kind of grating, formed by the solid parts between these holes, and resembling a honeycomb; and that the points of contact between the bladder and grating may be as few as possible, the holes are hexagonal, and the partitions are filed almost to an edge. The breadth of these hexagons is three-tenths of an inch, and consequently the surface nine times larger than common; and as the circumference is three times greater than that of the common valve, and the cohesion to be overcome is, in the first moment of the air's exerting its force, proportional to the circumference of the hole, the valve over any of these holes will be raised with three times more ease. Besides, the raising of the valve over the centre hole is aided on all sides by those that are placed round it; and as they all contribute as much to raise the bladder over the centre hole, as the air immediately acting under it, the valve will be raised with double the ease already supposed, or with a sixth part of the force commonly necessary. After the bladder begins to rise, it will expose a greater surface to the air underneath, which will cause it to move more easily.

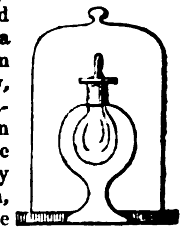
The celebrated experiment of the Madgeburgh hemispheres will serve as a practical illustration of the use of the air-pump.

Two hollow hemispheres, *b d*, constructed of brass, as represented in the diagram, are so formed, that when placed mouth to mouth they shall be in air-tight contact. They are furnished with handles, *c d*, one of which may be screwed off.

In the neck to which this handle is screwed, is a tube furnished with a stop-cock. The handle being screwed off, let the hemisphere be screwed on the pump plate, and the other hemisphere being placed over it, let the stop-cock be opened so as to leave a free communication between the interior of the sphere and the exhausting tube of the air-pump. The pump being now worked, the interior of the sphere will form the receiver from which all communication with the external air is cut off, and rarefaction will be produced in it to any degree which may be desired. This being effected, let the stop-cock be closed; and let the sphere be detached from the pump plate, and the handle screwed upon it. If then the two handles be drawn in opposite directions, so as to pull the hemispheres from one another, it will be found that they will resist with considerable force. If the diameter of the sphere be 6 inches, its section through the centre will be about 28 square inches. The hemispheres will be pressed together by a force amounting to 15 pounds for every square inch in the section. If 28 be multiplied by 15, we shall obtain 420, which is the amount of the force with which the hemispheres will be held together. If one of the handles be placed on a strong hook, and a weight of 400 pounds be suspended from the other, the weight will be supported by the pressure of the atmosphere.

This is one of the earliest experiments in which the effects of atmospheric pressure were exhibited. Otto Guericke, the inventor of the air-pump, constructed, in 1654, a pair of such hemispheres one foot in diameter. The section through the centre of these were about 113 square inches, which multiplied by 15 gives a pressure amounting to nearly 1,700 pounds. If the exhaustion were complete, the hemispheres would be held together by this force; but, even though incomplete, they were still able to resist a prodigious force tending to draw them asunder.

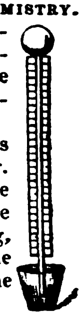
Another very beautiful experiment tending to illustrate the use of the air-pump and the phenomena of respiration may now be adverted to. The apparatus for the purpose is shewn in the figure.



It consists of a receiver placed on the pump plate, and enclosing a globular-shaped glass vessel, within which is contained a bladder. Now, in the ordinary process of respiration a partial vacuum is formed in the chest by the elevation of the ribs, and the air passing down by the ordinary passage of the mouth, enters the lungs and oxygenizes the blood. In the little apparatus above referred to, a vacuum is formed by the air-pump, and the bladder immediately expands; on the readmission of the air, it returns to its original dimensions, so that a series of expansions and contractions may readily be produced very analogous to the operations of nature.

Air Remedies, in *Surgery*. The application of gaseous matters to the purposes of surgery has not been sufficiently attended to. There is reason to believe that several æriform substances might be employed locally as well as internally, to considerable advantage; but it would exceed the limits we have prescribed to this department of our work, were we to adduce all the facts that might be brought forward to illustrate the medicinal powers of air in its different combinations. The application of fixed air, or carbonic acid gas, by means of fermentation, in cases of fetid and gangrenous ulcers is now well known. It has been advantageously used also in malignant ulcers of the nose, tongue, and mouth, as well as in caries of the bones.

Fixed air is plentifully obtained from a mixture of alkaline or chalky substances with vitriolic acid; and during the effervescence, applying the gas which is extricated immediately to the morbid part; or, by impregnating water with it, compresses may be soaked in the water, and laid frequently over the seat of the disease. The antiseptic properties of this gas may be shewn by suspending a piece of meat in common air, and a similar portion in the carbonic acid. It will be found that the one will retain its freshness, while the other will speedily decay. See Carbonic Gas and Chemistry.

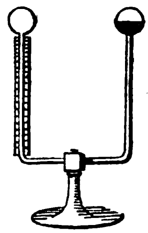


Air-Thermometer. The great susceptibility of air to the influence of caloric, has induced the chemist to employ it as a substitute for mercury and spirit of wine in the construction of thermometers.

The instrument which he employs consists of a tube furnished with a bulb containing air. The cup beneath is intended to hold a little coloured fluid, and if a portion of the air in the bulb be expelled by heat, it will, on cooling, re-ascend the tube, and indicate changes in the temperature of the surrounding bodies by the rise or fall of the coloured fluid.

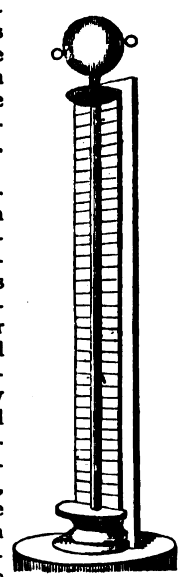
The double-air, or differential thermometcr, is a

modification of the above. This thermometer consists of a small glass tube bent into the shape of the letter U, and terminating at each extremity in a small hollow ball nearly of the same size; the tube contains a little sulphuric acid tinged red with carmine, and sufficient to fill the greatest part of it. The glass balls are full of air, and both communicate with the intermediate tube.



To one of the legs of the tube, as shown above, is affixed a small ivory scale, divided into 100 degrees; and the sulphuric acid is so disposed, that in the graduated leg its upper surface stands opposite to the part of the scale marked 0. The glass ball attached to the leg of the instrument to which the scale is attached, is by way of distinction called the focal ball. Suppose this thermometer brought into a warm room, the heat will act equally upon both balls, and expanding the included air equally in each, the liquor in the tube will remain stationary. But suppose the focal ball exposed to heat while the other ball is not; in that case, the air included in the focal ball will expand, while that in the other is not affected. It will therefore press more upon the liquid in the tube, which will of course advance towards the cold ball, and therefore the liquid will rise in the tube above 0, and the rise will be proportional to the degree of heat applied to the focal ball. This thermometer, therefore, is peculiarly adapted for ascertaining the degree of heat accumulated in a particular point, while the surrounding atmosphere is but little affected, as happens in the focus of a reflecting mirror. No change in the temperature of the room in which the instrument is kept is indicated by it, while the slightest alteration in the spot where the focal ball is placed is immediately announced by it.

Air-Thermometer, in *Electricity*. There are several forms of this apparatus described by the early electricians, neither of which are at all equal either on the score of utility or simplicity to the accompanying instrument by Mr. Ronalds.



This must be a much more substantial piece of apparatus than that employed for chemical purposes, and the ball should be somewhat larger in proportion to its size. It consists of a stand supporting a tube and bulb, the latter being provided with two wires and rings. If the object be to ascertain the amount of expansion by the electric shock, when passed through common air, a communication is made between the machine and the rings by a chain, and the expansion is shown by the depression of the coloured fluid in the tube. If any other gas be experimented on, a vacuum must be first formed by the air-pump, and the gas introduced.

Air-Vessels in *Navigation*. It is important that we should here notice an arrangement of tubes under this name, which has been introduced for the construction of ships at sea, and more especially for life-boats. Mr. Greathead, the inventor, first suggested *air-tanks*, but afterwards substituted long tube-formed air vessels, which were carried round the planking, and arranged in strata beneath the decks. In the event of a boat thus protected shipping a heavy sea, a number of persons may still be supported by the aid of the air-vessels. But the great use of this contrivence would be found in the event of a vessel foundering at sea. This circumstance has attracted the attention of a very ingenious gentleman of the name of Watson, who in a lecture lately delivered in the London Institution, demonstrated the practicability of applying air-vessels of this description to the whole British navy.

Ajutage, or Adjutage, in *Hydraulics*; the most essential part of any artificial fountain or water-pipe. There is so much discrepancy in the published experiments of various authors on this subject, that it may be advisable to give our readers an analysis of those most distinguished for their accuracy. We may commence with those of Bossut and Prony. The following is a comparison, by M. M. Bossut and Prony, of the theoretical with the real discharges from a simple ajutage one inch in diameter.

Constant weight of the water in the reservoir above the centre of the orifice.	Theoretical discharge through a circular orifice one inch in diameter.	Real discharges in the same time through the same orifice.	Ratio of the theoretical to the real discharges.
Paris feet.	Cubic inches.	Cubic inches.	
1	4381	2722	1 to 0·62133
2	6196	3846	1 to 0·62073
3	7589	4710	1 to 0·62064
4	8763	5436	1 to 0·62034
5	9797	6075	1 to 0·62010
6	10732	6654	1 to 0·62000
7	11592	7183	1 to 0·61965
8	12392	7672	1 to 0·61911
9	13144	8135	1 to 0·61892
10	13855	8574	1 to 0·61883
11	14530	8990	1 to 0·61873
12	15180	9384	1 to 0·61819
13	15797	9764	1 to 0·61810
14	16393	10130	1 to 0·61795
15	16968	10472	1 to 0·61716

Constant height of the water in the reservoir above the centre of the orifice.	Theoretical discharges through a circular orifice one inch in diameter.	Real discharges in the same time by a cylindrical tube, 1 inch in diameter and 2 inches long.	Ratio of the theoretical to the real discharges.
Paris feet.	Cubic inches.	Cubic inches.	
1	4381	3539	1 to 0·81781
2	6196	5002	1 to 0·80729
3	7589	6126	1 to 0·80724
4	8763	7070	1 to 0·80681
5	9797	7900	1 to 0·80638
6	10732	8654	1 to 0·80638
7	11592	9340	1 to 0·80573
8	12392	9975	1 to 0·80496
9	13144	10579	1 to 0·80485
10	13855	11151	1 to 0·80483
11	14530	11693	1 to 0·80477
12	15180	12205	1 to 0·80403
13	15797	12699	1 to 0·80390
14	16393	13177	1 to 0·80382
15	16968	13620	1 to 0·80270

To determine the relative quantities discharged by orifices of different forms, we must have recourse to the invaluable labours of Bossut, Michellotti, Smeaton, Poleni, Venturi, and Eytelwein, and we may commence with the experiments of Bossut, Michellotti, Brindley, and Smeaton, as deduced by Mr. Adcock:

That the quantities of fluid discharged in equal

times from different sized apertures, the altitude of the fluid in the reservoir being the same, are to each other nearly as the area of the apertures.

That the quantities of water discharged in equal times by the same orifice under different heads of water, are nearly as the square roots of the corresponding heights of the water in the reservoir above the centre of the apertures.

That, in general, the quantities of water discharged in the same time, by different apertures under different heights of water in the reservoir, are to one another in the compound ratio of the areas of the apertures, and the square roots of the altitudes of the water in the reservoirs.

That on account of the friction, the smallest orifice discharges proportionally less water than those which are larger and of a similar figure, under the same heads of water.

That from the same cause, of several orifices whose areas are equal, that which has the smallest perimeter will discharge more water than the other, under the same altitudes of water in the reservoir. Hence, circular apertures are most advantageous, as they have less rubbing surface under the same area.

That, in consequence of a slight augmentation which the contraction of the fluid vein undergoes, in proportion as the height of the fluid in the reservoir increases, the expenditure ought to be a little diminished.

That the discharge of a fluid through a cylindrical horizontal tube, the diameter and length of which are equal to one another, is the same as through a simple orifice.

That if the cylindrical horizontal tube be of a greater length than the extent of the diameter, the discharge of water is much increased.

That the length of the cylindrical horizontal tube may be increased with advantage to four times the diameter of the orifice.

That the diameters of the apertures and altitudes of water in the resevoir being the same, the theoretic discharge through a thin aperture, which is supposed to have no contraction in the vein, the discharge through an additional cylindric tube of greater length than the extent of its diameter, and the actual discharge through an aperture pierced in a thin substance are to each other as the numbers 16, 13, 10.

That the discharges by different additional cylindric tubes under the same head of water are nearly proportional to the areas of the orifices, or to the squares of the diameters of the orifices.

That the discharges by additional cylindric tubes of the same diameter under different heads of water are nearly proportional to the square roots of the head of water.

That from the two preceding corollaries, it follows, in general, that the discharge during the same time, by different additional tubes, and under different heads of water in the reservoir, are to one another nearly in the compound ratio of the squares of the diameters of the tubes, and the square roots of the heads of water.

The following are deductions from the experiments of M. Venturi:

That if the part of a compound tube nearest the reservoir have the form of a contracted vein, the expenditure will be the same as if the fluid were not contracted at all.

That if to the smallest diameter of a cone, a cylindrical pipe be attached, of the same diameter as the least section of the contracted vein, the discharge of the fluid will, in a horizontal direction be lessened by the friction of the water against the side of the pipe.

That if the same tube be applied in a vertical direction, the expenditure will be augmented, on the principle of the gravitation of falling bodies; consequently, the greater the length of pipe the more abundant is the discharge of fluid.

That if the additional compound tube have a cone applied to the opposite extremity of the pipe, the expenditure will, under the same head of water, be increased in the ratio of 24 to 10.

In order to produce this singular effect, the cone nearest the reservoir must be of the form of the contracted vein, which will increase the expenditure in the ratio of 12.1 to 10. At the other extremity of the pipe, a truncated conical tube must be applied, of which the length, nearly nine times the diameter at the smallest part, and its outward diameter must be 1.8. This additional cone will increase the discharge in the proportion of 24 to 10.

That in vertical tubes, the upper ends of which have the form of the contracted vein, the quantity of water discharged is that which corresponds with the height of the fluid above the inferior extremity of the tube.

That in compound conical tubes, the discharge of the fluid is increased in the proportion of the area of the section of the contracted vein, whatever may be the position of the tube, provided that its internal figure be adapted throughout to the lateral communication of the motion.

That by varying the divergence of the sides of the tubes, the lateral communication of motion has a maximum and a minimum of effect. The minimum of effect is when the angle made by the sides of the tube with each other exceeds sixteen degrees, and the maximum effect is when the same angle is about three degrees.

Discharge by bent tubes.—Experiments by M. Venturi.

Height of water in the reservoir 32.5 inches.	Time in which 4 Paris cubic feet were discharged.
Cylindrical horizontal tube, having the conical end of the form of the contracted vein:	
Diam. 14.5 lines.—Length 15 inches...	45″
Cylindrical curved tube, having a conical end similar to the last:	
Diam. 14.5 lines.—Length 15 inches..	50″
Cylindrical angular tube, having a conical end similar to the two preceding:	
Diam. 14.5 lines.—Length 15 inches...	70″

ALBUMEN. This substance owes its name to the Latin term for the white of egg. The white of an egg, however, is not pure albumen. It contains also some mucus, soda, and sulphur: but as albumen is never found perfectly pure, and as no method is known of separating it without at the same time altering the properties of albumen, chemists are obliged to examine it while in combination with these bodies.

Albumen dissolves readily in water, and the solution has the property of giving a green colour to vegetable blues, in consequence of the soda which it contains. When albumen it heated to the temperature of 165°, it coagulates into a white solid mass; the

consistency of which, when other things are equal, depends in some measure on the time during which the heat was applied. The coagulated mass has precisely the same weight that it had while fluid. This property of coagulating when heated is characteristic of albumen, and distinguishes it from other bodies.

The taste of coagulated albumen is quite different from that of liquid albumen: its appearance, too, and its properties, are entirely changed; for it is no longer soluble, as before, either in hot or cold water.

The coagulation of albumen takes place even though air be completely excluded; and even when air is present, there is no absorption of it, nor does albumen in coagulating change its volume. Acids have the property of coagulating albumen, as Scheele ascertained. Alcohol also produces, in some measure, the same effect. Heat, then, acids and alcohol, are the agents which may be employed to coagulate albumen.

It is remarkable, that if albumen be diluted with a sufficient quantity of water, it can no longer be coagulated by any of these agents. Scheele mixed the white of an egg with ten times its weight of water, and then, though he even boiled the liquid, no coagulation appeared. Acids, indeed, and alcohol, even then coagulated it; but they also loose their power if the albumen be diluted with a much greater quantity of water, as has been ascertained by many experiments. Now, when water is poured into albumen, its integrant particles must be farther separated from each other, and their distance must increase with the quantity of water with which they are diluted. We see, therefore, that albumen ceases to coagulate wherever its particles are separated from each other beyond a certain distance. That no other change is produced, appears evident from this circumstance, that whenever the watery solution of albumen is sufficiently concentrated by evaporation, coagulation takes place, upon the application of the proper agents, precisely as formerly.

It does not appear that the distance of the particles of albumen is changed by coagulation; for coagulated albumen occupies precisely the same sensible space as liquid albumen.

Now, to what is the coagulation of albumen owing? We can conceive no change to take place from a state of liquidity to that of solidity, without some change in the figure of the particles of the body which has undergone that change. Now such a change may take place three ways: 1. The figure may be changed by the addition of some new molecules to each of the molecules of the body. 2. Some molecules may be abstracted from every integrant particle of the body. 3. Or the molecules of which the integrant particles are composed, may enter into new combinations, and form new integrant particles, whose form is different from that of the old integrant particles. Some one or other of the following circumstances must take place during the coagulation of albumen.

Scheele and Fourcroy have described the coagulation of albumen to the first of these causes, namely, to the addition of a new substance. According to Scheele, caloric is the substance which is added. Fourcroy, on the contrary, affirms that it is oxygen.

Scheele supported his opinion with that wonderful ingenuity which shone so eminently in every thing which he did. He mixed together one part of the white of an egg, and four parts of water, added a little pure alkali, and then dropt it into as much muriatic acid as was sufficient to saturate the alkali. The albumen coagulated. But when he repeated the experiment, and used carbonate of alkali, instead of pure alkali, no coagulation ensued. In the first case, he says, there was a double decomposition: the muriatic acid separated from a quantity of caloric, with which it was combined, and united with the alkali; while, at the same instant, the caloric of the acid united with the albumen, and caused it to coagulate. The same combination could not take place when the alkaline carbonate was used, because the carbonic acid gas carried off the caloric, for which it has a strong affinity.

Fourcroy observes, in support of his opinion, that the white of an egg is not at first capable of forming a hard coagulum, and that it only acquires that property by exposure to the atmosphere. It is well known that the white of a new laid egg is milky after boiling; and that if the shell be covered over with grease to exclude the external air, it continues long in that state; whereas the white of an old egg, which has not been preserved in that manner, forms a very hard, tough coagulum. These facts are undoubted; and they render it extremely probable, that albumen acquires the property of forming a hard coagulum only by absorbing oxygen: but they by no means prove that coagulation itself is owing to such an absorbtion. And since coagulation takes place without the presence of air, and since no air, even when it is present, is absorbed, this opinion cannot be maintained without inconsistency.

The only substance which can be supposed to leave albumen during coagulation, since it does not lose its weight, is caloric. We know that in most cases where a fluid is converted into a solid, caloric is actually disengaged. It is extremely probable, then, that the same disengagement takes place here. But the opinion has not been confirmed by any proof. Fourcroy indeed says, that in an experiment made by him, the thermometer rose a great number of degrees. But as no other person has ever been able to observe any such thing, it cannot be doubted that this philosopher has been misled by some circumstance or other to which he did not attend.

The coagulation of albumen resembles exactly what takes place when concentrated silicated potash is exactly saturated with muriatic acid. The mass slowly assumes an opal colour, and at last concentrates into a solid gelatinous mass. Now this jelly consists of the particles of silica combined with each other, and with a certain portion of water. These particles were formerly held in solution by the potash; that is to say, the affinity of the silica for potash was superior to the cohesive force which exists between the particles of silica. The muriatic acid, by saturating the potash, diminished the force of its affinity for the silica. The cohesive force of the silica, now superior, causes it to combine in masses, consisting of a certain portion of silica and water. These masses, equally diffused through the liquid, and at such small intervals as to cohere together, gives the whole a gelatinous form. Something like this seems to take place with respect to the albumen. Its particles, combined with water and also with soda, are all kept at equal distances in the liquid; because this affinity just balances their cohesive force. But when heat is applied, this affinity is diminished by the additional elasticity, or tendency to separate, given to the water and the soda. The cohesion of the albumen, now superior, causes its particles to combine in sets, form-

ing solid bodies, equally distant from each other, and cohering together. Hence the gelatinous form, and the solidity of the coagulum, always inversely proportional to the quantity of water present. Thus it appears, that whatever diminishes the affinity between the water and soda and the albumen, occasions its coagulation, by allowing its cohesive force to act.

Albumen, then, is capable of existing in two states; the one before it has been coagulated, and the other after it has undergone coagulation. Its properties are very different in each. It will be proper, therefore, to consider them separately.

Albumen in its natural state, or uncoagulated, is a glary liquid, having little taste, and no smell. When dried spontaneously, or in a low heat, it becomes a brittle, transparent glassy-like substance; which, when spread thin upon surfaces, forms a varnish, and is accordingly employed by book-binders for that purpose. When thus dried, it has a considerable resemblance to gum arabic, to which also its taste is similar. The white of an egg loses about four-fifths of its weight in drying. It is still soluble in water, and forms the same glary liquid as before.

From the experiments of Dr. Bostock, it appears that when one part of this dry albumen is dissolved in nine parts of water, the solution becomes perfectly solid when coagulated by heat; but if the albumen amounts only to $\frac{1}{15}$th of the liquid, then, though coagulation takes place, the liquid does not become perfectly solid, but may be poured from one vessel to another.

When one grain of albumen is dissolved in 1000 grains of water, the solution becomes cloudy when heated.

Uncoagulated albumen soon putrefies unless it be dried; in which state it does not undergo any change. It putrefies more readily when dissolved in a large quantity of water than when concentrated. The smell of white of egg, allowed to run into putrefaction, resembles that of pus.

It is insoluble in alcohol or ether, which immediately coagulate it, unless it be mixed with a great proportion of water, in which case even acids have no effect.

When acids are poured upon it, coagulation takes place equally; but several of them have the property of dissolving it again when assisted by heat. This at least is the case with sulphuric acid. The solution is of a green colour, and does not soon blacken, even when boiled. It is the case also with nitric acid, and probably also with muriatic acid. Nitric acid first disengages some azotic gas; then the albumen is gradually dissolved, nitrous gas emitted, oxalic and metallic acids formed, and a thick oily matter makes its appearance on the surface.

Albumen, Vegetable. The discovery of albumen in vegetables is due to Fourcroy. This chemist having observed that the clarification of the expressed juices of the antiscorbutic plants was effected by the spontaneous coagulation of their colouring matter at the temperature of boiling water, was induced to examine whether this property did not depend on the presence of albumen. For this purpose, having obtained the juice of two pounds of young cresses, he filtered it while cold, through blotting paper, and by this means separated the grosser parts of the colouring fecula: the liquor was, however, still of a bright green, but upon being exposed in a broad shallow vessel to the air, at a temperature of about 80° Fah., in two hours it became turbid, and deposited a greenish matter, becoming itself almost colourless; in this state it was exposed to the heat of boiling water, and in a few minutes there separated a large quantity of whitish flocculent matter. Another portion of the same clarified liquor being exposed to the air, deposited at the end of two days a similar coagulum; and the same effect was produced on the third portion by the addition of sulphuric acid. The substance thus obtained being first repeatedly washed in cold water, exhibited all the properties of animal albumen. It was easily and quickly dissolved by any of the alkalies; it experienced no change in boiling water, except that of becoming more solid; it converted the purple juice of mallows to green, and by distillation, yielded a notable quantity of ammonia: when exposed with a little water to a warm air, it swelled considerably, exhaled a fetid ammoniacal odour, and gave all the usual signs of active putrefaction; hence explaining the reason of the rank disagreeable smell that characterises the spontaneous decomposition of all the cruciform plants. When dried, by pressure between two pieces of paper, it exhibited a considerable degree of ductility and transparence, like glue.

Albumen was afterwards found in the roots of various vegetables, especially of the rumexpatientia; also in wheat and the farinaceous seeds; and in general in all the green and succulent parts of plants. The acid pulps of fruits are totally destitute of this substance, but abound with jelly; and it is the opinion of Fourcroy, that in all these cases there is a conversion of albumen into jelly, by the gradual evolution of the acid, and consequent fixation of oxygen.

Alchemy. This ancient and highly poetical forerunner of the science of chemistry has much that is interesting in its early history and progress. Sober utilitarian science would have found but few supporters in the early dawn of alchemy, but the visionary prospect of realizing vast treasures by the fortunate labour of a happy day, nay of a single moment, when the stars were propitious, induced many persons to waste their lives and fortunes in the vague attempt at discovering the formation of the philosopher's stone, the elixir of life, or some other equally absurd phantasy.

The golden age of alchemy most ominously commenced with the conquests of Arabian fanaticism in Asia and Africa, the destruction of the Alexandrian library, and the subjection of Europe to the basest superstition, and the most profound ignorance. The Saracens, lively, subtle, credulous, and nurtured in fables of talismans, and the celestial influences, admitted with eager faith the wonders of alchemy, and condescended to receive instruction from slaves whom they had conquered; the rage of making gold spread through the whole Mahometan world, and in the splendid courts of Almanzor, Haroun-al-Raschid, and Abdallah Almammon, the professors of the Hermetic art found patronage, disciples, and emolument. Geber, Rhazes, Albufaragius, and Avicenna, the most celebrated physicians and chemists of the Arabian school, were deeply tinged with the prevailing insanity. From the 10th to the 13th century, little is known concerning the state of alchemical studies; the descendants of the Arabian warriors had begun to acquire a taste for science when their thrones were shaken by the Crusades, and finally overthrown by the desolating deluge of the Turkish barbarians. The

arts again retiring from Egypt and Syria, rested for a moment at Constantinople, and then withdrew to the western provinces of Europe. In the 13th century Albertus Magnus, Roger Bacon, and Raymond Lully, appeared as the great revivers of alchemy and chemistry; for from this time, although alchemical pursuits were esteemed the noblest and most important, yet they ceased to occupy entirely the attention of experimental philosophers. The writings of these able men raised the study of alchemy to a degree of credit which it little merited, especially among the ecclesiastics, who possessed at that time almost all the learning of the age; and even a pope, John XXII., was weak enough to assert, in his treatise on the art of transmutation, that he had himself made 200 ingots of gold, of the weight of 100 pounds each. The 15th century exhibits the same combination of chemistry and alchemy; but in which it is pleasing to observe a great dimunition of reserve with regard to the processes of common chemistry, which are for the most part told in very plain language by the men who, when treating of alchemy, are utterly unintelligible. The great authors during this period are George Ripley and Basil Valentine. A portrait of the latter philosopher, and a view of his study, may not be out of place, especially as it will serve to convey a notion of a laboratory of the period.

Hitherto alchemy had been confined to the single object of changing the baser metals into silver and gold, and the materia medica consisting wholly of vegetable and animal preparations, there existed little or no connexion between the chemists and physicians. The prevalence, however, of the leprosy, and the rise and rapid progress of a variety of diseases, rendered it necessary to have recourse to more potent remedies. The Asiatic practice of physic, with regard to the use of mercury, was introduced with the happiest effects by Carpus; antimony found an able advocate in Basil Valentine, whose *Currus Triumphalis Antimonii* is a curious mixture of enthusiasm and knowledge. The credit of the Galenists began to be shaken, and chemistry by thus associating to itself the most philosophical of the three learned professions, acquired an immense accession of abilities. The unexpected success which attended the first medical use of chemical preparations, awakened a new hope in the minds of the alchemists; and this was no less than the discovery of an universal medicine which should heal all disorders, and prolong the duration of human existence to an indefinite period. The great authors of this sect were Paracelsus and Vanthelmont, who by their vigorous use of opium and mercury, effected a number of important cures, impossible to the common Galenical practice of the age. About the same time flourished Henry Cornelius Agrippa and George Agricola, the first of whom, half knave and half enthusiast, belongs decidedly to the alchemical party; but the latter, though bewildered in youth by the false philosophy of his time, made ample amends to the cause of true science in his maturer years, by his admirable treatise on metallurgy and mineralogy. From this time we meet with few authors of reputation who wrote professedly on alchemy, though a kind of half belief in the thing still clung about even the most eminent chemists, as may be clearly traced in their writings. A bold attempt to support the falling cause was made in the beginning of the 17th century by the Rosicrucians, a secret society which originated in Germany, and attracted the attention of the rest of Europe for 25 years. By pretending, however, to too much, even to more than the ancient chemists when even in the plenitude of their power and influence ever arrogated to themselves—the fraternity made few converts, and speedily sunk into total discredit.

Volumes have been written on the subject of alchemy: no person, however, has done such perfect justice to this interesting part of chemistry as professor Brande, who, amongst other authorities in favour of the successful labours of the alchemists, quotes that of Bergman, himself a distinguished chemist. In summing up the evidence of various authors for and against the possibility and probability of transmutation, Bergman observes, that "although most of them are deceptive, and many uncertain, some bear such character and testimony, that unless we reject all historical evidence, we must allow them entitled to confidence." For my part, the perusal of the histories of transmutation appears to me to furnish solid grounds for a diametrically opposite opinion. They are all of a most suspicious character: sometimes the fraud was open and intentional, seconded by juggling dexterity; at other times the performers deceived themselves; they purchased what was termed a powder of projection, prepared by the adepts, containing a portion of gold, and when they threw it into the fire with mercury, and found that portion of gold remaining in their crucible, they had not wit enough to detect its source; but the cases which are quoted as least exceptionable, are often exactly those which are really impossible; I mean, where the weight of the powder of projection, and of the lead or other base metal taken conjointly, was exceeded by that of the gold produced. Such is Hearne's history of Payknl's transmutation; who, with six drachms of lead and one of powder, produced an ingot that was coined into 147 ducats; and many others. But the most celebraled history of transmutation is that given by Helvetius, in his brief of the *Golden Calf:* discovering the rarest miracle in nature, how by the smallest portion of the philosopher's stone a great piece of common lead was totally transmuted into the purest transplendent gold, at the Hague, in 1666: and, as it is a luminous epitome of all that has been done on this subject, it may be better briefly to abridge the proceedings: "The 27th day of December, 1666, in the afternoon, came a stranger to my house at the Hague in a plebeick habit, of honest gravity and serious authority, of a mean stature, and a little long face, black hair, not at all curled, a beardless chin, and about 44 years (as I guess) of age, and born in North Holland. After salutation, he beseeched me

with great reverence to pardon his rude accesses, for he was a lover of the pyrotechnical art, and having read my treatise against the sympathetic powder of Sir Kenelm Digby, and observed my doubt about the philosophic mystery, induced him to ask me if I really was a disbeliever as to the existence of an universal medicine which would cure all diseases, unless the principal parts were perished, or the predestined time of death come. I replied, I never met with an adept, or saw such a medicine, though I had fervently prayed for it. Then I said, surely you are a learned physician? No, said he; I am a brass-founder, and a lover of chemistry. He then took from his bosom-pouch a neat ivory box, and out of it three ponderous lumps of stone, each about the bigness of a walnut. I greedily saw and handled for a quarter of an hour this most noble substance, the value of which might be somewhere about twenty tons of gold, and having drawn from the owner many rare secrets of its admirable effects, I returned him this treasure of treasures with a sorrowful mind, humbly beseeching him to bestow a fragment of it upon me in perpetual memory of him, though but the size of a coriander-seed. No, no, said he; that is not lawful: though thou wouldst give me as many golden ducats as would fill this room—for it would have particular consequences—and if fire could be burned of fire, I would at this instant rather cast it all into the fiercest flames. He then asked if I had a private chamber whose prospect was from the public street; so I presently conducted him to my best-furnished room backwards, which he entered," says Helvetius (in the true spirit of Dutch cleanliness), "without wiping his shoes, which were full of snow and dirt. I now expected he would bestow some great secret on me, but in vain. He asked for a piece of gold, and opening his doublet, showed me five pieces of that precious metal which he wore upon a green riband, and which very much excelled mine in flexibility and colour, each being the size of a small trencher. I now earnestly again craved a crumb of the stone, and at last, out of his philosophical commiseration, he gave me a morsel as large as a rape-seed: but, said I, this scanty portion will scarcely transmute four grains of lead. Then, said he, deliver it me back; which I did, in hopes of a greater parcel: but he, cutting off half with his nail, said, even this is sufficient for thee. Sir, said I, with a dejected countenance, what means this? And he said, even that will transmute half an ounce of lead. So I gave him great thanks, and said I would try it, and reveal it to no one. He then took his leave, and said he would call again next morning at nine. I then confessed, that while the mass of his medicine was in my hand the day before, I had secretly scraped off a bit with my nail, which I projected on lead, but it caused no transmutation, for the whole flew away in fumes. Friend, said he, thou art more dexterous in committing theft than in applying medicine: hadst thou wrapt up thy stolen prey in yellow wax, it would have penetrated and transmuted the lead into gold. I then asked if the philosophic work cost much, or required long time; for philosophers say that nine or ten months are required for it. He answered, their writings are only to be understood by the adepts, without whom no student can prepare this magistery. Fling not away, therefore, thy money and goods in hunting out this art, for thou shalt never find it. To which I replied, as thy master showed thee, so mayest thou perchance discover something thereof to me, who know the rudiments; and therefore it may be better to add to a foundation than begin anew. In this art, said he, it is quite otherwise; for unless thou knowest the thing from head to heel, thou canst not break open the glassy seal of Hermes. But enough; to-morrow at the ninth hour, I will tell you the manner of projection. But Elias never came again: so my wife, who was curious in the art whereof the worthy man had discoursed, teazed me to make the experiment with the little spark of bounty the artist had left me. So I melted half an ounce of lead, upon which my wife put in the said medicine: it hissed and bubbled, and in a quarter of an hour the mass of lead was transmuted into fine gold, at which we were exceedingly amazed. I took it to the goldsmith, who judged it most excellent, and willingly offered fifty florins for each ounce."

Such is the celebrated history of Elias the artist, and De Helvetius; and such may be considered as the general tenour of the alchemical attempts of the period. We must not, however, omit to state, that the alchemists have materially assisted in the advancement of chemistry, both by real discoveries, and by the invention of nearly all the implements now employed in chemical research.

It is not a little remarkable, that while Europeans have studied alchemy for the express purpose of acquiring gold, the Chinese, so early as the reign of Woote (B. C. 140), were engaged in pursuing the same object. It is stated, that one Le-shaou-keun (a priest of the Taou sect) advised his majesty to re-establish the worship of the god of the furnace; asserting that from red oxide, gold could be obtained. He also affirmed, that if temples were erected to the Sëen genii, or spirits, they would come and confer on his majesty a woo-sze-yŏ, a medicine that would prevent death. The emperor, in compliance with the advice given, worshipped the furnace, and ordered priests to put to sea in quest of the island Pung-lae, the abode of the immortals. It is said that Le-shaou-keun, like many in the west, died just before he succeeded in making gold. During the 12th year of this reign, as is gravely stated, the priest Lan-ta thus addressed his majesty: "Having repeatedly put to sea, I have seen the spirit Gan-te, who has instructed me how to make gold, and how to obtain the medicine that tends to immortality; and can also induce them to visit this place." Lan-ta in consequence received an important appointment, and a princess was given him in marriage. His deceptive arts however being discovered, he was in consequence beheaded.

ALCOHOL. This term is applied exclusively to the purely spirituous portions of those fluids which have undergone the vinous fermentation.

Alcohol is considerably lighter than water, viz. in the proportion of 800 or 820 to 1000. The lightest that can be obtained, by simple distillation from spirit of wine, has the specific gravity of 825. By the intervention of substances which strongly attract water, Chaussier brought it to the specific gravity of 798, and Lovitz and Saussure, jun. to 791 or 792. Alcohol of the specific gravity 820 still contains, according to Lovitz, about $\frac{1}{10}$th its weight of water. When of the specific gravity 920, it has been called *proof spirits*; the term *above proof* being used to denote a spirit lighter than this, and *under proof* one which contains a larger proportion of water. Rectified spirit is directed by the *London Pharmacopœia* to have the specific gravity of 835, but it seldom exceeds

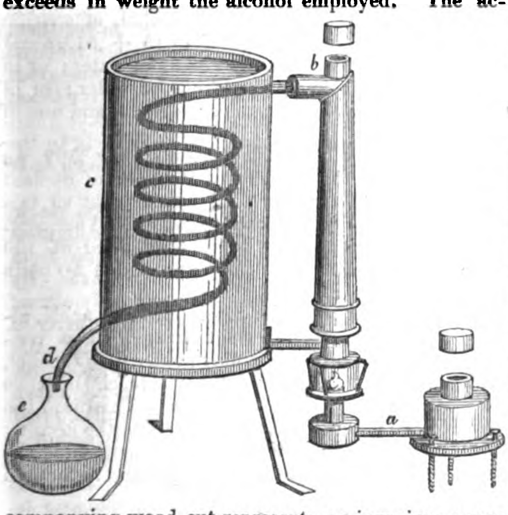
840. The quantity of alcohol and water in mixtures of different specific gravities, may be learned from Mr. Gilpin's copious tables, of which the following is an abstract.

Table showing the specific gravity of the mixture of alcohol and water.

Centesimal parts of the Mixture.	Specific Gravities. According to Chaussier.	According to Gilpin (last Table.)
Alcohol . . . 100	0.7980	0.825
95	0.8165	0.83887
90	0.8340	0.85244
85	0.8485	0.86414
80	0.8620	0.87606
75	0.87525	0.88762
70	0.8880	0.89883
65	0.9005	0.90941
60	0.9120	0.91981
55	0.9230	0.92961
50	0.9334	0.93882
45	0.94265	0.94726
40	0.9514	0.95493
35	0.95865	0.96158
30	0.96535	0.96736
25	0.97035	0.97239
20	0.97605	0.97723
15	0.9815	0.98213
10	0.9866	0.98737
5	0.99335	0.99327
0	0.99835	1.00000

Alcohol unites chemically with water; and caloric is evolved during this union. Equal measures of alcohol and water, each at 50° Fahrenheit, give by sudden admixture an elevation of nearly 20° of temperature; and equal measures of proof spirit and water an increase of 9½°. The bulk of the resulting liquid is less also than that of the two before admixture.—Thus a pint of alcohol and a pint of water, when the mixture has cooled to the temperature of the atmosphere, falls considerably short of two pints.

Alcohol is highly inflammable. During its combustion, carbonic acid is generated; no charcoal appears; and a quantity of water is produced which exceeds in weight the alcohol employed. The accompanying wood-cut represents an ingenious apparatus employed by Lavoisier for the purpose of ascertaining this fact.



It consists of a spirit-lamp *a*, over which is placed a perpendicular tube *b*; within this is contained a second tube of considerably smaller diameter, and the space between is filled with sand in order to preserve the temperature of the inner one. This again communicates with the worm of the tub *c*, and terminates in the bottle attached at *d*. The quantity of alcohol contained in the lamp having been accurately determined, flame is applied, and the vapour formed during the combustion of the spirit, passing through the tube *a* becomes condensed in the worm, and in that state is received in the bottle *e*. Lavoisier adds, that by a careful attention to keeping water in the condensing tub always cold, we may obtain 17 ounces of water from the combustion of 16 ounces of alcohol.

The flame of alcohol acquires a red colour from muriate of lime, a deep blood-red from the muriate of strontites, and a green tinge from boracic acid.

Alcohol is a fluid which is remarkably expansible by heat. Dividing the scale between the freezing and boiling points of water into two equal parts, M. De Luc has stated that alcohol expands 35 parts for the first 90°, and 45 parts for the second 90°. The strength of his alcohol, however, is described only by the indefinite test of its firing gunpowder. Mr. Dalton found that 1000 parts of alcohol of the specific gravity .817 at 50° Fahrenheit become 1079 parts at 170°. At 110°, half way between the two extremes, the alcohol was at 1039, or half a division below the true mean. The more the alcohol is diluted with water, the greater he found the disproportion between the two parts of the scale. When of the specific gravity .967, answering to 75 per cent. water, the ratio of expansion through the first half between 50° and 170°, was to that through the second half as 35 to 45, which is precisely the same as De Luc gives for pure alcohol. In reporting these results no account is taken of the expansion of the glass vessel, and consequently the real expansions may be considered as rather exceeding the apparent ones which have been stated.

Alcohol boils at 176°. If water be added, its boiling point is proportionably raised; so that the temperature at which it boils, is not a bad test for its strength. At this degree of heat, it is converted into a vapour, which may be exploded by passing an electric spark through a mixture of it with oxygen gas.

Alcohol of the specific gravity .8152 at 50° Faht., gives a gas, the density of which is 1½ times that of the atmosphere. To become gaseous, alcohol absorbs 0.436, the caloric required to vaporize an equal weight of water.

It has never yet been congealed by any known method of producing artificial cold. Even when diluted with an equal weight of water, it requires a cold of 6° below 0 to congeal it. Mr. Hutton has given in the *Edinburgh Encyclopædia*, under the article *Cold*, an account of his having succeeded several years since in solidifying alcohol by a cold of —110°, but the process by which he accomplished it has not yet been published. The alcohol he employed had a density of .798 at 60°.

Alcohol is a powerful solvent. It dissolves soap; vegetable extract; sugar; oxalic, camphoric, tartaric, gallic, and benzoic acids; volatile oils; resins; and

balsams. It combines also with sulphur, phosphorus, and the pure alkalies; but not with their carbonates. Of the class of salts with alkaline, earthy, and metallic bases, alcohol dissolves some copiously, others sparingly, and others not at all. The proportion in which some of these are taken up, is stated in the following Table by Wenzel, the principal defect of which is the omission of the specific gravity of the alcohol employed.

Two hundred and forty grains of boiling alcohol dissolve of

	Grains.
Borate of ammonia	1
Fluate of alumine	1
——— ammonia	1
Muriate of ammonia	17
——— lime	288
——— magnesia	1313
——— potash	5
Nitrate of alumine	240
——— ammonia	214
——— lime	288
——— magnesia	694
——— potash	5
——— soda	23
Oxalate of alumine	7
Tartrate of alumine	7
——— ammonia	7
——— potash	1
Super-tartrate of potash	7
——— oxalate of potash	7

Mr. Kirwan, also, has given us a very useful Table, showing the power of alcohol at different specific gravities to dissolve several of the neutral salts. The salts were first deprived of their water of crystallization, and were digested, during three days, with alcohol, the temperature of which never exceeded 80° Fahrenheit.

	100 grains of alcohol at				
	.900	.872	.848	.834	.817
Sulphate of soda	0	0	0	0	0
——— magnesia	1	1	0	0	0
Nitrate of potash	2.76	1	0	0	0
——— soda	10.5	6	...	0.38	0
Muriate of potash	4.62	1.66	...	0.38	0
——— soda	5.8	3.67	...	0.5	
——— ammonia	7.5*	4.75	...	1.5	
——— magnesia	21.25	...	23.75	36.25	50
——— barytes		...	0.29	0.18	0.09
crystallized	1.56	...	0.43	0.32	0.06
Acetate of lime	2.4	...	4.12	4.75	4.88

Some salts, also, when actually dissolved in water, are precipitated by the addition of alcohol. This is the case chiefly with the sulphates, several of which are precipitated immediatley, while others are not separated without the application of heat and a few days' repose.

Alcohol, when transmitted through a red-hot copper tube, is decomposed. The tube is found lined with a very fine light soot resembling lamp-black, and an enormous quantity of carburetted hydrogen gas is evolved, not less, as appears from an experiment of Van Marum, than ten cubic feet by the decomposition of three ounces of alcohol. From the analysis of this gas, Mr. Cruickshank has inferred that in alcohol the carbon is to the hydrogen in the proportion of 4 to 1.*

* Nicholson's Journal, v. 7.

In order to determine accurately the composition of alcohol, Lavoisier burned a quantity with very minute attention to the products. The weight of alcohol consumed amounted to 93.5 grains, and 110.32 grains of oxygen were expended in the combustion. The water produced amounted to 106.2 grains, and the carbonic acid to 93.8. From the known quantity of carbon in carbonic acid, and of hydrogen in water, Lavoisier inferred that the alcohol, on which he operated, consisted of

Carbon	28.53
Hydrogen	7.87
Water (existing in the alcohol)	63.6
	100.00

Comparing, then, the composition of alcohol with that of sugar (a compound, as has already been stated, of 8 parts hydrogen, 64 oxygen, and 28 carbon), the same distinguished philosopher was led to the conclusion that, during the vinous fermentation, part of the carbon, by uniting with the oxygen, passes to the state of carbonic acid, and that the remaining carbon, with the hydrogen of the sugar, composes alcohol. If, therefore, it were possible to combine carbonic acid and alcohol, sugar ought to be regenerated.

An analysis of alcohol has been executed with considerable skill by M. de Saussure, by passing the vapour of alcohol at 62° and of the specific gravity of .830 through a red-hot narrow porcelain tube which communicated with a glass one about six feet in length, and refrigerated by ice. A gas was produced, which on analysis resolved itself into carbonic acid and water; and the alcohol was thus proved to contain

Carbon	51.98
Oxygen	34.32
Hydrogen	13.70
	100.00

Beside the hydrogen necessary to form water with the 34.32 parts of oxygen, there are 9.15 parts of hydrogen in excess. Now it is remarkable that this excess of hydrogen is to the carbon in alcohol (51.98) in the same proportions as the hydrogen is to the charcoal of olefiant gas; and we are, therefore, entitled to consider 100 parts of alcohol, of specific gravity .792, as constituted of (9.15 + 51.98 =) 61.13 parts of olefiant gas and 38.87 of water; or of two atoms of olefiant gas, and one of water; or of two atoms of charcoal, three of hydrogen, and one of oxygen.

In 100 parts of alcohol, specific gravity .792, we have, therefore, the elements of 100 parts of olefiant gas, united with those of 63.6 water. But as this alcohol may still be supposed to contain 8.3 per cent. water, real alcohol is probably constituted of 100 parts of the elements of olefiant gas, and of 50 parts of water.

By distillation with the more powerful acids, alcohol undergoes an important change. It is converted into a liquid considerably lighter than alcohol, and much more volatile and inflammable, and miscible only in small proportion with water. This fluid has received the generic name of *ether;* and the peculiar varieties are distinguished by adding the name of the acid, by the intervention of which they have been prepared.

Table of the quantity of alcohol, of specific gravity .825 at 60° Fah. in various Wines, &c.

Kind of Wine.	100 Measures contain	Kind of Wine.	100 Measures contain
Port, average	23.48	Frontignac	12.79
Ditto, highest	25.83	Coti Roti	12.32
Ditto, lowest	19	Roussillon	17.26
Madeira, highest	24.42	Cape Madeira	18.11
Ditto, lowest	19.34	Cape Muschat	18.25
Sherry, average of 4	19.19	Constantia	19.75
Claret, ditto of 3	14.43	Tent	13.30
Calcavella	18.10	Sheraaz	15.52
Lisbon	18.94	Syracuse	15.28
Malaga	17.25	Nice	14.63
Bucellas	18.49	Tokay	9.88
Red Madeira	18.40	Raisin Wine	25.77
Malmsey Madeira	16.40	Grape Wine	18.11
Marsala	25.87	Currant Wine	20.55
Ditto	17.26	Gooseberry ditto	11.84
Red Champagne	11.30	Elder Wine	9.87
White ditto	12.80	Cider	9.87
Burgundy	14.53	Perry	9.87
Ditto	11.95	Brown Stout	6.80
White Hermitage	17.43	Ale	8.88
Red ditto	12.32	Brandy	53.39
Hock	14.37	Rum	53.68
Ditto	8.88	Hollands	51.60
Vin de Grave	12.80		

Some doubt may, perhaps, be excited of the accuracy of this table, by a reference to the comparative intoxicating effects of port wine and brandy, the latter of which certainly are more than double those of the former. But it is to be remembered, that, in wine, the alcohol is in a state of combination with other ingredients, which must necessarily diminish its activity on the animal system.

The above very interesting particulars are chiefly from the scientific pages of Dr. Henry.

While speaking of alcohol, we must not omit to point out a new process for procuring it which is now carried on to a considerable extent in the metropolis. It has long been known that alcohol must of necessity be liberated during the fermentation of bread, but it was left to the persevering researches of the present period to turn this scientific fact to beneficial account. Large bakeries have lately been erected for the purpose of manufacturing bread and collecting the spirit which is thus produced; and this is effected by the use of a close oven, and refrigeratory, somewhat similar to the ordinary process of distillation.

Alcove, in *Architecture;* the recess or part of a chamber which was formerly used in most civilized countries as a dormitory. The word is derived from the Spanish alcoba, which, according to the older dictionaries of that language, signifies a vaulted cabinet in a chamber, open on one side, without windows, and large enough to contain a bed. The Spanish word is derived from the Arabic al kubbeh, the alcove, the place for the bed, and alkubbeh is probably from alkubbaun the tent, or more probably from khaub, sleep, alkhaub, the bed, alkaab, the cave. The relation of these words is curious. According to the Spanish description, an alcove is not unlike a cave or recess in a rock, in which a wandering Arab might make his abode for the night.

Alcoves in ordinary rooms are square recesses, conformable to the definition we have given, and are finished in a style corresponding with the apartments to which they belong, and with flat or vaulted ceilings as taste may direct, or the height of the alcove may require: but in chambers of greater magnificence, and rooms of parade, they are not always recesses; but more properly a portion of a large apartment separated from the rest by an arch, or balustrade, a screen of columns, or some other decorations, and elevated a few steps above the general level of the floor. On this elevated platform a state bed is usually placed, and sometimes seats and sofas to entertain company. This is what the French architects denominate an alcove. The recess to which the English have appropriated the term, and which is conformable to its primary signification, the French denominate a niche, as may be seen in *Blondel de la Decoration des Edifices en general.*

The authors of the *Encyclopédie Méthodique* are of opinion, that alcoves were in use among the ancients, and this would be indisputably true if we could receive the term in the lax sense in which they have explained it. But we cannot give the name of alcoves to the enclosures which they mention, consisting of a kind of moveable balustrade hung round with drapery, and placed in any part of a chamber at pleasure; nor to those draperies supported by terms, or affixed to the wall, which frequently occur in antique basso-relievos. It must be confessed, that we know very little of the private apartments of the ancients; yet, if a recess for the bed to stand in had been a fashionable feature in a Greek or Roman bed-chamber, it is probable that it would have been mentioned by Vitruvius or others, and especially by Pliny, who is so minute and particular in the description of his Laurentine and Tusculan villas. In each of these villas he describes a small elegant retired closet, furnished with a bed, which by means of glass folding-doors and curtains, could be occasionally laid into or separated from the adjoining apartment. These closets appear to have been somewhat similar to alcoves, but they differ essentially from modern alcoves in having windows.

Ale. A fermented liquor, obtained from an infusion of malt and hops. This liquor, the natural substitute of wine in such countries as could not produce the grape, was originally made in Egypt, the first planted kingdom on the dispersion from the east, that was supposed unable to produce grapes. And as the Noachin colonies pierced farther into the west, they found, or thought they found, the same defect, and supplied it in the same manner. Thus the nations of Spain, the inhabitants of France, and the aborigines of Britain, all used an infusion of barley for their ordinary liquor; and it was called by the various names of *cælia* and *ceria* in the first country, *cerevisia* in the second, and *curmi* in the last; all literally importing *strong water.*

"All the several nations (says Pliny) who inhabit the west of Europe, have a liquor with which they intoxicate themselves, made of corn and water. The manner of making this liquor is somewhat different in Gaul, Spain, and other countries, and is called by many various names, but its nature and properties are every where the same. The people of Spain, in particular, brew this liquor so well, that it will keep good a long time. So exquisite is the cunning of mankind in gratifying their vicious appetites, that

they have thus invented a method to make water itself intoxicate." The method in which the ancient Britons, and other Celtic nations, made their ale, is thus described by Isidorus and Orosius: "The grain is steeped in water and made to germinate, by which its spirits are excited and set at liberty; it is then dried and grinded; after which it is infused in a certain quantity of water; which being fermented becomes a pleasant, warming, strengthening, and intoxicating liquor." This ale was most commonly made of barley; but sometimes of wheat, oats, and millet.

Anciently the Welsh and Scots had also two kinds of ale, called *common ale* and *spiced ale;* and their value was thus ascertained by law: "If a farmer hath no mead, he shall pay two casks of spiced ale, or four casks of common ale, for one cask of mead." By this law, a cask of spiced ale, 9 palms in height, and 18 palms in diameter, was valued at a sum of money equal in efficacy to 7*l.* 10*s.* of our present money, and a cask of common ale, of the same dimensions, at a sum equal to 3*l.* 15*s.* This is a sufficient proof that even common ale in this period was an article of luxury among the Welsh, which could only be obtained by the great and opulent. Wine seems to have been quite unknown even to the kings of Wales in this period, as it is not so much as once mentioned in their laws; though Giraldus Cambrensis, who flourished about a century after the conquest, acquaints us that there was a vineyard in his time at Maenarper, near Pembroke, in South Wales.

Ale was the favourite liquor of the Anglo-Saxons and Danes, as it had been of their ancestors the ancient Germans. Before their conversion to Christianity, they believed that drinking large and frequent draughts of ale was one of the chief felicities which those heroes enjoyed who were admitted into the hall of Odin.

There are various sorts of ale known in Britain, particularly *pale* and *brown;* the former is brewed from malt slightly dried, and is esteemed more viscid than the latter, which is made from malt more highly dried or roasted.

In order to make a strong keeping ale of an excellent quality, the following should be the proportion of the ingredients: forty bushels of best pale malt and fifty pounds of hops. For the first mash, ten barrels of water at 172° may be let on and raked for half an hour, and then allowed to stand for an hour. Water at 180° may then be leaked or let on so as to run through the malt, and to wash away all the wort soaked in the previous mash. These two liquors, when boiled down with the hops, fermented, and finished, ought to produce eight barrels of ale at 100 pounds' gravity on Dicas's saccharometer. But in the one mash the malt is by no means exhausted of its saccharine matter, although what remains is not of so fine a quality as that which had been dissolved away. The same malt and hops will, however, answer extremely well for making table-beer; and with this intent a second mashing may be made with water of 185°, and even a third with water of 190°; the quantities being such, that after boiling on the same hops, fermenting, and finishing, there will be twelve barrels of beer at thirty pounds' gravity.

An inferior, but yet a good ale may be made from forty bushels of prime pale malt, and thirty pounds of good hops. The mashing heat may be as before, and it may be calculated as before to produce both ale and beer. In this case, twelve barrels of ale at seventy pounds' gravity, and ten barrels of beer at thirty pounds will be produced. Or, if the object is merely to obtain ale at seventy pounds' gravity, the quantity producible will be fourteen barrels. If table-beer of a good quality, without any ale, is required, the quantity of materials to produce thirty barrels of finished beer should be, malt forty bushels, good hops twenty-five pounds, as much water as will produce thirty-five barrels of hopped wort; and this will finish about thirty barrels of beer. In calculating the quantity of water necessary to produce a given quantity of a first mash, it will be of use to know that an imperial bushel of ground malt absorbs and retains about 6¼ imperial gallons of water.

The Burton ale having attained a very high character for its strength and flavour, it may be advisable to point out the process by which it is prepared. It is made from the palest malt and hops; for, if it be not pale as straw, it will not pass with the connoisseurs in that article; and the gravity being so very high as thirty-six to forty pounds a barrel, makes it a matter of great nicety to get malt sufficiently pale.

If the malt be not very good, only one mash must be made for this liquor; but if it be good, two mashes may take place, adverting still to the great specific gravity which ought to be produced.

The heat of the liquor should be 185°, or 190°, adding 5° for the second mash.

If only one wort be made, it may be boiled an hour and a quarter; if two, they may be boiled three-quarters of an hour the first, and an hour, or an hour and a quarter the second; remembering that long boiling is prejudicial to the colour.

The quantity of hops must be three-quarters of a pound per bushel of malt, or more, according to circumstances; but the more that are used, though an advantage as a preservative, the higher will be the colour of the ale.

The heat of fermentation should not much exceed 75°, and as the first heat would thence probably be about 55°, the quantity of yeast, both on account of this circumstance, and the great weight of the wort, should not be less than three pounds per barrel, used as is before recommended; and the rule for cleansing is the same as that before inculcated.

It is to be racked into clean casks (without hops) when nearly pure, and the sizes of them are from 32 to 42 or 43 gallons (called *half hogsheads*), and from 70 to 80 gallons (called *hogsheads*), which are generally hooped with an equal number of iron and wooden hoops; the latter are white, flat, or broad bark hoops; a bar is put across each head, and the brewer's initials or name, with B, or Burton at length, are branded in front in letters of about an inch and a quarter high; and the number of gallons which the casks holds is cut with a scribe-iron, just above the cork-hole.

The bung-hole is not above an inch and a quarter in diameter, which is stopped with a wooden shive or bung, and a piece of triangular tin-plate is afterwards nailed over it. See Beer and Porter.

Alembic. This is a very useful chemical instrument, and is used for distillation, when products are of too volatile a nature for the use of the retort. It is indeed a sort of matrass with a capacious head fitted to it, and from the head proceeds a tube or beak, like the neck of a retort. As the external circumference or base of the head is lower than the beak, the vapours which rise and are condensed against its

sides, first run down into the channel formed by the depressed part, and thence are conveyed off by the beak. The alembic is a more complex instrument than the simple retort, which with care will answer as well, except, perhaps, for those bodies which are partly vapourized, and partly sublimed; in which case the sublimed part is very conveniently retained by the head.

Algebra, is that part of mathematics in which symbols are employed for the purpose of abridging and generalizing the reasonings which occur in the solution of questions relative to numbers. By some writers it is used synonimously with analysis, but there is this distinction between the two, that algebra is the science which relates to the calculation of magnitudes in general, and analysis, the method of resolving mathematical poblems by the aid of algebra.

The earliest treatise on Algebra which has been transmitted to the present times, is that of Diophantus of Alexandria, who flourished about the middle of the fourth century of the Christian era. It consisted of thirteen books, the first six of which only are now extant. They were printed in the form of a Latin translation, by Xylander, in 1575, and afterwards in Greek and Latin, with a commentary by Bachet, in 1621; and subsequently, in 1670, with corrections and marginal annotations by Fermat. The investigations contained in these do not extend beyond quadratic equations, and the expression is that of common language assisted by a few symbols. Notwithstanding that this is the earliest production we possess on this subject, there are strong reasons for believing that algebra, as well as our ordinary system of notation, originated with the Hindus; who have been found to possess some valuable works of this nature, containing rules and principles that do not appear to have been derived from any foreign source. The chief of these performances are the *Cuttaca d'haya*, and the *Ganita d'haya* of Brahmagupta, a Hindu astronomer and mathematician who flourished about the latter end of the sixth century, and the *Bija Ganita* and *Lilavati* of Bhascara *Acharya*, another astronomer of the same nation, who lived about the year 1150. From this latter work, it appears that besides a knowledge of most of the common rules of algebra, the Hindus were at that period acquainted with some branches of the science which were not known in Europe till the latter end of the seventeenth, and middle of the eighteenth century.

Europe, however, owes its first acquaintance with this science to the Arabians, from whom, through the medium of commerce, it was introduced into Italy early in the thirteenth century, by Leonardo Bonacci, a merchant of Pisa, two of whose manuscripts, dated 1202, and 1228, are mentioned by Cossali. Many manuscript writings of a similar nature to these appeared soon afterwards in various parts of Italy; but the first printed works on the subject are those of Lucas Paciolus, de Burgo Santi Sepulchri, whose principal production is that entitled *Summa Arithmeticæ et Geometricæ, Proportionumque et Proportionalium*, which was published in 1469. From this performance, which exhibits the state of the science towards the latter end of the fifteenth century, it appears that the earlier European analysts, as well as those of Arabia, used no symbols or signs to represent either quantities or the operations that it was necessary to perform on them, with the exception of a few verbal abbreviations. The letters *p* and *m* were used to denote plus and minus; and it is laid down as a rule to be observed in multiplication, that *plus* into *minus* gives *minus*, but *minus* into *minus* gives *plus*. Thus the first appearance of algebra is merely that of a system of short-hand writing, or a contraction of common language applied to the solution of arithmetical problems.

Soon after the publication of the work last mentioned, and about the year 1505, Ferrei, a professor of Bologna, discovered a method of solving one of the cases of a compound cubic equation. Ferrei was followed by the famous Cardan, who extended his rule, for a particular case, to all the forms and varieties of cubic equations, whether complete or incomplete, and also possessed an acquaintance with the number and nature of their roots, both positive and negative, possible and impossible, or imaginary. The resolution of equations of the third degree was followed close by that of biquadratic equations, or those of the fourth degree, which was discovered by Louis Ferrari, one of the pupils of Cardan. About the same period, the study of the science of algebra was prosecuted in Germany with vigour, particularly by Stifel and Scheubel, the former of whom, in his *Arithmetica Integra*, frequently employs letters to represent numbers, and was the first to introduce the symbols $\times$, —, and $\surd$, to express addition, subtraction, and extraction of a root; but neither this writer nor Scheubel, who published his work in 1552, speak of cubic equations, which were, however, fully treated of by Peter Roth, another German mathematician of that age. In the year 1557, appeared *The Whetstone of Witte, which is the seconde parte of Arithmeticke, containing the Extraction of Rootes, the Cossike Practice, with the Rules of Equations, and the Woorkes of Surde Nombers*," by Robert Recorde, a native of Wales. This treatise contains a method of extracting the roots of compound algebraical quantities; and it is the first in which we meet with the use of the sign $=$ to represent equality. The several works of Pelletier, Peter Nunez, Bombelli, and Stevin, published at the latter end of the sixteenth and beginning of the seventeenth century, are abundant proofs of the zealous cultivation of algebra in their respective countries of France, Portugal, Italy, and Flanders; but it is chiefly to the celebrated Vieta, master of requests under Margaret of France, that we must attribute its subsequent rapid progress, in consequence of the improvements which he introduced into the system of notation by the employment of the capital letters of the alphabet to denote all kinds of quantities, whether known or unknown, the former being designated by consonants and the latter by vowels. This illustrious man also invented new demonstrations of the rule for resolving cubic, and even biquadratic equations, and partly discovered the general relation between the roots of those of any degree and the co-efficients of their terms, provided all those roots be real or positive, and none of the terms be wanting. Vieta was followed by Albert Girard, who greatly extended the partial discovery of the former, of the successive formation of the co-efficients of an equation from the sum, of its roots, and the sum of their products, whether they be positive or negative. Among the most eminent analysts of this period we must not omit our celebrated countryman Thomas Harriot, who introduced the use of the small letters of the alphabet instead of the capitals employed by Vieta, and who, by a slight improvement which he made in algebraical

language, laid the foundation of the most important branches of that science. We allude to the method of writing an equation in the form of $x^2+ax-b=o$ instead of $x^2+ax=b$.

By this succession of discoveries the algebraic analysis was prepared for the step about to be taken by Descartes, and which forms one of the most important epochs in the history of the mathematical sciences. This was its application to define the nature and investigate the properties of curve lines, and consequently to represent the notion of variable quantity.

Although undoubtedly previous to the time of this distinguished philosopher great progress had been made in researches purely algebraical, yet the notation in use was exceedingly imperfect, and encumbered with ideas of actual relation to magnitude which inseparably connected every algebraic quantity with notions of extension and solidity. The principal object and utility of algebra is, however, to express purely and without reference to any particular values which may be assigned to them, the abstract relations of quantities. That this object might be attained, it was absolutely necessary to disentangle the science from all those extraneous considerations which limited its application and extension. This was the first service rendered to algebra by Descartes; and the metaphysical character of this illustrious man's genius was of singular utility to him in the performance of it. According to the method of notation then in vogue, the product of any quantity multiplied by itself once, was indicated by annexing to that quantity the geometrical figure called the square; and that of a quantity multiplied by itself twice, by a delineation in perspective of the solid known by the name of the cube. These operations were also denoted respectively by the letters Q and C placed above the quantity to be multiplied, and sometimes by a mere repetition of the letter which designated that quantity the same number of times that it was to be made a factor; in other words, according to the ordinary mode of expressing multiplication. In the place of this embarrassing notation which fettered and impeded the exercise of thought on the subjects which it was intended to enlighten, Descartes substituted one, clear, simple, and general. Instead of the letters Q and C, which were simply verbal abbreviations, he placed above the quantity to be multiplied the figure which denoted the number of times which the operation of multiplication was to be performed, or its *power*. The great value of this important alteration will be fully appreciated by a simple inspection of some of the algebraical expressions which occur in the writers on this subject who preceded Descartes, and by a comparison of their complicated confusion with the simplicity and perspicuity which they assume from the introduction of exponents. By means of this and other improvements, the leading principles of algebra were more thoroughly unfolded, and the notation was converted from a mere collection of abbreviated forms of common language, into a system of symbolical writing capable of being applied with the greatest advantage to aid the operations of the mind.

We have now rapidly traced the science of algebraic analysis from its origin and early form, to the period when it attained a degree of perfection little short of that which it has reached at the present day. Succeeding authors are too numerous, and with a few bright exceptions, their improvements too inconsiderable to merit any minute mention. To Newton we are indebted, amongst other things, for his well known demonstration of the *Binomial Theorem*; and his *Reversion of Series*, or method of finding the value of the root of an infinite series, in terms of another series of a different kind; both of which inventions are rendered universal by means of the general exponent which he first introduced into analytical operations. The zealous labour bestowed on the theory of series during the last two centuries, has also been productive of great advantage to this science, and the researches of the Bernoullis, Taylor, Demoivre, Stirling, Euler, and Leibnitz, have greatly improved and extended that important branch of algebraic analysis.

NOTATION.

The object of algebra is, as we have before observed, to assist the operations of the mind in the consideration of questions relative to number. The method in which this object is attained, and the utility of that method, may be best shown by reference to a question of that nature. Let it be proposed

To divide a given number into two parts, such that one shall be greater than the other by a given excess.

By the conditions of the question,

1°. *The greater of the two parts is equal to the lesser increased by the given excess.*

Therefore if the lesser be known by adding to it the excess, we shall obtain the greater.

2°. *The greater part added to the lesser makes up the whole number.* Substituting in this last sentence, in the place of the expression *the greater part*, the equivalent to it in 1°, we find that

The lesser part increased by the given excess, added to the lesser part, makes up the whole number. But the lesser part added to the lesser part, is the lesser part taken twice; therefore,

Twice the lesser part increased by the given excess make up the whole number. Or the given excess must be added to twice the lesser part in order to make up the whole number; but if twice the lesser part *with* the given excess be *equal to* the whole number, *without* the excess it will be *less than* that number by so much as the excess; or

Twice the lesser part is equal to the whole number diminished by the given excess. Therefore,

The lesser part is equal to the half of the difference between the whole number and the given excess.

From this last sentence we perceive, that to obtain the lesser of the two required parts, it is only necessary to perform simple arithmetical operations on the whole number and the given excess, both of which are known. Thus, if the number to be divided be 14, and the excess of the one of the parts into which it is to be divided above the other, 6, the lesser part will be equal to the half of, 14 diminished by 6, which is 4; and the greater which is equal to the whole diminished by the lesser, will be 10.

We observe that, in the reasonings by which we have been enabled to obtain the above conclusion, several expressions, such as *added to, diminished by, is equal to*, &c. occur repeatedly; it is evident, therefore, that, if instead of writing those expressions, we employed a symbol to represent each of them whenever it occurred, a very material abridgement would ensue. It is on this account that various symbols are used in algebra; each of which serves to indicate that a certain operation is to be performed on the quantities to which it is attached.

The sign +, which is read *plus*, and is termed the

sign of addition, or the positive sign, indicates, the addition of the quantities before which it is placed to some other. Thus $15+28$ is 15 *plus* 28, or 15 increased by 28.

The sign —, which is read *minus*, and called the sign of subtraction, or the negative sign, serves to denote the subtraction of the quantity to which it is prefixed from some other. Thus $32-18$ is 32 *minus* 18, or 32 diminished by 18.

The sign $\times$ is used for multiplication, and has the same signification with a point placed between the quantities to be multiplied. Thus 22×58 or 22.58 is 22 multiplied by 58, and represents the product of 22 by 58, both of which are termed the factors of that product.

The sign $\div$ indicates division, which is however more generally represented by writing the divisor below the dividend with a horizontal stroke between them; thus $6 \div 3$ or $\frac{6}{3}$ means that 6 is to be divided by 3.

When two quantities are equal to one another, their relation is denoted by $=$ placed between them. Thus $8=4+4$ means that 8 *is equal to* $4+4$, and is termed an equation.

When two numbers are unequal, their relation is expressed by the sign of inequality $\angle$ or 7, the open part of the symbol being always turned towards the greater number. Thus $20 \; 7 \; 13$, means that 20 is greater than 13, and $10 \angle 13$, that 10 is less than 13.

By the substitution of these signs, whenever the operations which they represent are to be indicated, in the place of directions to the same effect expressed in ordinary language, our reasonings in regard to quantities and the operations to be performed on them must be greatly simplified. Thus, if we wish to denote that a certain quantity is to be added to another, and that from their sum a third quantity is to be subtracted, we have only to write, first quantity + second quantity + third quantity. But it is obvious that even this abridged form is susceptible of still further abridgment by substituting for first, second, and third quantity, any symbols which we shall agree to stand respectively for those terms; as for instance, three of the letters of the alphabet.

We may thus concisely express the above proposition by $a+b+c$, having previously agreed that in this particular case a shall represent what we have termed first quantity, b second quantity, and c third quantity.

The great advantage of this mode of expression is that the most complicated reasonings are at once presented in a very simple form; so that the mind being enabled to comprehend them as it were at a glance, is at liberty to direct all its energies to the solution of the question which is their object.

We may illustrate this by recurring to the question with which we commenced, namely, that in which it is required to divide a given number into two parts, such that one shall be greater than the other by a given excess, and deducing the same conclusion as then, through the same reasoning, expressed however by means of the system of representative symbols which we have just unfolded.

Let a represent the given number to be divided, b the given excess, and x the lesser of the two parts into which it is required to divide a; then $x+b$ will represent the greater. By the conditions of the question,

$$x+x+b=a$$

$$\text{Or } 2x+b=a$$

$$\text{Therefore } \quad 2x=a-b$$

$$\text{And } \quad x=\frac{a-b}{2}$$

$$\text{Or } \quad =\frac{a}{2}-\frac{b}{2}$$

Having thus found the lesser part, we may easily obtain the greater, which is represented by $x+b$, and which, therefore, $=\frac{a}{2}-\frac{b}{2}+b$, or $\frac{a}{2}$ diminished by one half of b, and increased by the whole of b, which is

$$\frac{a}{2}+\frac{b}{2}$$

The correctness of our operation we may test by adding together the results obtained for the two parts, which, according to the conditions should be equal to the whole number to be divided. Thus, $\frac{a}{2}-\frac{b}{2}$ added to $\frac{a}{2}+\frac{b}{2}$, is the half of a added to the half of a, or the whole of a, first diminished and then increased by the half of b, two operations, the latter of which neutralizes the former, and which consequently have no effect on a, which remains the sum of the addition. Hence our results fulfil the conditions required, and are therefore correct. The student may observe that we have represented the whole number and the given excess by a and b, and the part which it is required to find by x. In so doing, we have only conformed to a long-established and highly convenient usage, that of designating all the known quantities in an expression by the early letters of the alphabet, and the unknown by the concluding ones. By this arrangement we are enabled, in collecting on the opposite sides of an equation the different terms composing these two classes, immediately to distinguish to which any quantity belongs.

In addition however to the abridgement effected by the ordinary method of employing representative symbols for the purpose of indicating the performance of certain operations, a variety of abbreviations occur in the application of that method, especially to quantities designated by letters.

Thus, when numbers represented by letters are to be multiplied together, the ordinary signs of multiplication may be dispensed with, and the operation will be equally indicated by writing the letters in succession one after the other. Thus, $a\,b$ has the same signification as $a \times b$, or $a.b$, and abc, the same as $a \times b \times c$, or $a.b.c$. This mode of expression must evidently be confined to letters; for in the common system of notation, a very different meaning is attached to a similar arrangement of figures. Thus, 8×4, or 8 multiplied by 4, if written 84, would be confounded with the number *eighty-four*.

When a number designated by a letter is to be added to itself several times, the letter is written only once, and before it is placed the figure which marks how many times it occurs, and which is termed its *co-efficient*. Thus, instead of $x+x+x+x+x+x$, we write $6x$, when we wish to express that x is to be added together six times; and 6 is the co-efficient of x.

When a similar quantity is to be multiplied by

itself several times, in this case also the letter is written only once, and above it to the right is placed the number which denotes how often it is a factor, and which is termed its *index*, or *exponent*. Thus, $a \times a$, or $a\,a$, is written a^2, and is called the *square*, or *second power* of a; $a \times a \times a$, or aaa, a^3, and is termed the *cube*, or *third power* of a; $a \times a \times a \times a$, or $aaaa$, is denoted by a^4, and is the *fourth power* of a; and a^n is the n^{th} power, and represents a quantity composed of the factor a occurring n times, whatever number n may represent.

In connection with the raising of powers is another operation directly the reverse, called the extraction of roots. The *root* of any quantity is another quantity, which, multiplied by itself a certain number of times according to the denomination of that root, produces the first quantity. Thus, the *square root*, or, as it might more properly be termed, the *second root* of a, is a quantity, which, multiplied by itself once, or raised to its square or second power, will produce a; the *cube root* or *third root* of a, is a quantity which, when multiplied by itself twice, or raised to its cube or third power, will give a; and the fourth root of a is one, which when multiplied by itself three times, or raised to its fourth power, will also produce a. The operation of extracting a root of any quantity is denoted by prefixing to that quantity the *radical sign* $\surd$, and writing above it the number denoting the power or degree of the root to be extracted. The square root of a is expressed by $\sqrt[2]{a}$, or more simply by $\sqrt{a}$, the cube root by $\sqrt[3]{a}$, the fourth root by $\sqrt[4]{a}$, and the n^{th} root by $\sqrt[n]{a}$.

It is particularity necessary for the beginner thoroughly to understand the distinction between such expressions as $3a$, and a^3, as from an insufficient attention to this point arise much perplexity and confusion. He should remember the operations by which each of them respectively is obtained; that $3a$ represents the addition of a three times, and a^3 the multiplication of a three times; that in the latter case the number 3 is an *exponent*, in the former, merely a *co-efficient*. The difference will become still more apparent by writing out a few such expressions at full length, as in the following examples:

$$\begin{aligned}
a^2 &= a \times a \\
2a &= a + a \\
a^3 \times b^2 &= a \times a \times a + b \times b \\
3a + 2b &= a + a + a + b + b \\
a^6 &= a \times a \times a \times a \times a \times a \\
6a &= a + a + a + a + a + a
\end{aligned}$$

We now proceed to explain the mode of effecting the ordinary operations of arithmetic upon algebraic quantities or numbers represented by letters, prefixing however a few preliminary definitions and observations.

DEFINITIONS.

Every collection of numbers written in the language of algebra is termed an expression. Thus, $x + y$ is the algebraical expression for the sum of the numbers x and y; and $3x - 8y + 42$ is the algebraical expression for the number x taken three times, diminished by y taken eight times, and increased by z taken four times.

The different portions of which an expression is composed, and which are connected together by means of the signs $\times$ and $-$, are called the *terms* of that expression. Thus $3x$, $8y$, and $4z$, are the terms of $3x - 8y + 4z$.

Quantities may consist of one or more terms; in the former case, they are called *monomials*, or simply *terms;* in the latter, they are designated by the general appellation of *polynomials*. They are also called *binomials* when the number of terms is two, and *trinomials* when three.

When we wish to indicate that any operation is to be performed on a quantity consisting of more than a single term, it is necessary to enclose that quantity in brackets, or draw a line over it. Thus $(a + b)\ (c + d)$ or $\overline{a + b}.\ \overline{c + d}$, means that the sum of a and b is to be multiplied by the sum of c and d; and is thus written in order to distinguish it from $a + b.\ c + d$, which means simply that to a is to be added the product of b and c, and that the sum is to be increased by d. Again, $a - (b - c)$ means that from a is to be taken b, diminished by c; $a - b - c$ would signify that both b and c were to be subtracted instead of merely their difference being so. An attention to this point is also indispensable, in indicating the operation of raising powers; as for instance, $(a + b)^3$ denotes that the sum of a and b is to be multiplied by itself twice; while $a + b^3$ merely implies that b singly is to be multiplied by itself that number of times, and the product added to a.

The numerical value of an algebraical expression is the number which would result from the performance of all the operations indicated in that expression, were particular values assigned to the different letters contained in it; and generally varies with those values. Thus the numerical value of $4a^2$ is 16 when $a = 2$; 36 when $a = 3$; and 64 when $a = 4$.

The numerical value of a polynomial is not changed by altering the order of its terms, provided the particular sign of each be retained. For instance, $a + b$ means that b is to be added to a, and $b + a$, that a is to be added to b; but the results of these two additions are evidently the same; therefore, if for the one expression we substitute the other, we do not affect its value. Similarly, $3a + b - 4c$, may be written $b + 3a - 4c$, or $b - 4c + 3a$, or $3a - 4c + b$, or $-4c + 3a + b$, it being particularly understood in this last expression that $4c$ is considered as to be subtracted from what follows it. It should, however, be well remembered that all these are different expressions, and that the operations indicated in each of them are perfectly distinct; and that we substitute them one for another, not because the operations indicated in each are the same, but because when performed they lead to the same conclusions.

Of the different terms of a polynomial, some are preceded by the sign $+$, some by that of $-$; the former are called *positive* terms or quantities, and the latter *negative* ones. Using these symbols in the signification which we have attached to them, a positive quantity is a quantity to be added, and a negative quantity a quantity to be subtracted. The performance of either of these operations necessarily implies a connection with some other quantity; for we cannot add a quantity unless we have something to which to add it, or subtract one unless we have something from which to subtract it. Hence, according to this definition, an isolated term to which either of the signs $+$ or $-$ is prefixed, such as $+a$ or $-a$, is unintelligible; it directs us to perform upon a single term an operation, to the performance of which two are essential. There is, it may be remarked, an extention of the use of the sign $+$, to which we shall come presently, introduced purely for the sake of

convenience, and which consists in regarding the first term of an expression to which no sign is prefixed, to be as effectually preceded by + for all the purposes of certain operations, as if + actually stood before it; and also a conventional usage of both + and —, in a sense somewhat different from, though analogous to, that conveyed by the ordinary definition; of this latter we shall speak hereafter.

Each of the literal factors composing a term is said to be a *dimension* of that term, and the number of its dimensions determines its *degree*. Thus, $2a$ is a term of one dimension, or of the first degree; $8\,ab$, one of two dimensions, or of the second degree, and $10\,a^2\,b^3\,c^4$, one of nine dimensions, or of the ninth degree, the factor a occurring twice, b three times, and c four times. Similarly, $3\,a^8\,b^6\,c^7\,d^9$ is a term of twenty-four dimensions, or of the twenty-fourth degree; and upon taking a number of terms similar to this and the preceding, in which each of the letters has an exponent attached to it, we should find that generally the degree or number of dimensions of a term may be ascertained by the addition of the exponents of the letters contained in it. But this rule evidently cannot apply to the case of $8ab$, neither of the letters of which has any exponent; but it will apply if we slightly extend our notation of exponents, and represent a and b, as according to analogy they ought to be represented, namely by a^1 and b^1, which we may term *first powers* of a and b. We are thus enabled to comprise under one rule that which would otherwise require two.

Like terms are those which consist of the same letters raised to the same powers, and which differ, if at all, only in their co-efficients; as $2ab$ and $4ab$, $6b^2\,a^3\,b^2$ and $22a^3\,b^2$. When they differ in other respects, they are called *unlike terms*. It frequently happens that several of the terms of a polynomial are alike; in such a case it is capable of being simplified. Thus, $4a + 2ab^2 + 8b - 6ab^2 - 3b + 12ab^2 - 3ab^2 - 2b$, may be written $4a + 2ab^2 + 12ab^2 - 6ab^2 - 3ab^2 + 8b - 3b - 2b$, without altering its value; but ab^2 taken twice, added to ab^2 taken twelve times, is evidently ab^2 taken $2 + 12$, or 14 times; and $14ab^2$ diminished, first by 6 times and then by 3 times ab^2, is the same as $14ab^2$ diminished by 9 times ab^2, which is $5ab^2$. Similarly, 8 times b, diminished by 3 times b and by twice b, is 3 times b; therefore the original polynomial may be reduced to the form of $4a + 5a^2\,b + 3b$. From this and other examples of this sort, we deduce the following rule for the reduction of the like terms of an expression:—Collect into a single term all the like terms preceded by +, by adding together their co-efficients and prefixing the sum as a co-efficient to the literal portion common to all; in a similar manner collect into a single term all the like terms preceded by —; if the co-efficient of the former of the single terms thus obtained be as great as that of the latter, subtract that of the latter from it, and the term obtained by prefixing the difference to the literal portion common to both, will be the lowest reduced form of the given expression; but if the co-efficient of the former of the single terms be not so great as that of the latter, the latter preceded by its sign of subtraction must be written after the former, as an indication of the operation, and the expression thus obtained will be the lowest reduced form.

There are however two cases in which this rule does not apply, namely, when any one of the like terms has no co-efficient, and when any one has no sign. Thus $a + 3a$ is an expression, both the terms of which are like, and which we perceive by writing it at full length is equal to $4a$; but if we reduce it according to the rule, we obtain only $3a$, a result which is too small. The rule is therefore inapplicable to this case, and for this reason, that it proceeds upon the supposition of every term possessing a co-efficient, while from the sense in which we employ that symbol, a letter occurring singly, as a, has none. But it will be rendered applicable, and we shall obtain a correct result if we extend our definition of a co-efficient as we have already extended that of an exponent, and represent a as from analogy it might be represented, namely, by $1a$. We therefore consider a always to stand for $1a$, or rather taking into account our late extension of the meaning of exponent for $1a^1$, although it is simply written a.

The second case in which the rule is inapplicable is when the first term of a polynomial, which has no sign prefixed to it, is one of the like terms. The meaning we have attached to the signs + and — is that of symbols serving to connect one quantity with other quantities, by being prefixed to those others, and to denote that certain arithmetical operations are to be performed on them by means of the first one. But the first quantity being that to which the operations on the others are to be referred, is not considered to be added to, or subtracted from, any previous one, and therefore has no sign placed before it. Our rule embraces only the cases in which every one of the like terms is preceded by a sign; but it may be rendered applicable to those in which none is prefixed to the first term, by supposing that term to be for the purposes of this operation, preceded by +; and the results obtained by proceeding on this supposition will be correct.

ADDITION.

The addition of quantities consisting of a single term is indicated by connecting them with the sign +; thus $a + b$ means that b is to be added to a. We cannot actually perform the operation so indicated, because the letters a and b signify nothing in themselves: we express the sum of 6 and 4 by 10, because each of those numbers possesses a definite meaning, which enables us to say that the idea we attach to their sum is the same with that which we attach to the number 10. But as a and b are indefinite symbols with our ideas of which no particular values are connected, their sum must necessarily be indefinite also, until we assign some value to them. When we write $a + b$ then, we do not actually perform an addition, but rather indicate that that operation is to be performed when values are given to a and b.

Again, $8a^2\,b$, $6a^2b$ and $13\,a^2\,b$ are to be added together; their sum is represented by $8\,a^2b + 6\,a^2b + 13\,a^2b$. This expression we observe is capable of reduction, as it contains like quantities; and the result of that operation is $27\,a^2\,b$.

Hence the addition of monomials consists strictly in merely connecting the quantities to be added by the sign +; the subsequent simplification of the expression so obtained is referred to the operation of reduction.

Let it be required to add the polynomial $c - d$ to that of $a - b$. If we add c to a, we obtain $a + c$; this sum is, however, too much, for it is not a which is to be increased by c, but $a - b$, or a diminished by b; it must therefore be decreased by b, and will become

$a + c - b$; but the result which we have is again too great, because it is not c which is to be added, but $c - d$, or c diminished by d; we must therefore decrease it by d, and it will then become $a + c - b - d$, or $a - b + c - d$. Similar reasonings might be applied to other polynomials, and we may hence deduce this rule for the addition of two or more polynomials. Write the proposed quantities in succession one after the other, preserving to each term its respective sign, and simplify the result by the reduction and collection into one term of all the like quantities.

It is evident that this rule cannot apply to the first term of a polynomial which is to be added, when that term has no sign prefixed to it. Thus, in proceeding to add $c - d$ to $a - b$, according to the rule, we find that c has no sign by which to connect it with that expression. If we look, however, to the result which we obtained, without reference to the rule, we find that c is preceded by the sign $+$. Hence, in order to produce a correct result according to the rule, we must suppose c in the expression $c - d$ to be preceded by $+$. Further examples would give similar results; hence, in order to avoid the necessity of a second rule, to apply specially to the first term when it has no sign, we consider that term to be for the purposes of this operation, preceded by $+$, although that sign is not actually placed before it, as by so doing we are enabled to obtain correct results.

SUBTRACTION.

Let us proceed to subtraction; $4b$ is to be subtracted from $6a$, the result is expressed by $6a - 4b$. Similarly, $11ab^2$ subtracted from $15ab^2$, is $15ab^2 - 11ab^2$, or $4ab^2$.

Again, it is required to subtract the polynomial $a - b$ from c, which operation is indicated by $c - (a - b)$. We must, however, reduce this expression to one polynomial; for that purpose we take a from c, and obtain $c - a$; but we have taken too much from c, for it is not a that is to be subtracted from that quantity, but a diminished by b; the result must therefore be increased by b, in order to restore the excess of what we have taken above what we ought to have taken, and it then becomes $c - a + b$. If the polynomial to be subtracted from c be $a + b$, both a and b are to be subtracted, and the result is $c - a - b$. Or our two results are,

$$c - (a - b) = c - a + b,$$
$$c - (a + b) = c - a - b.$$

From these we observe, that to subtract $a - b$ from c, we have simply written it after that quantity, with this alteration however of prefixing to each of its terms the contrary sign to that which was attached to it in the original form. It is evident that the same result must be obtained in the subtraction of quantities of more than two terms, in short of any polynomials, and hence we derive the following rule: To subtract a polynomial, write it after the quantity from which it is to be subtracted, at the same time changing the sign of every one of its terms from $+$ to $-$, or from $-$ to $+$, and simplify by the reduction of the like quantities.

With regard to that portion of the rule which relates to the changing of signs, it is evident that in order to render it applicable to terms which have no sign at all, we must, as in the case of the operation of addition, consider such terms to be preceded by $+$. By an attention to this point, we shall be enabled to obtain correct results in all cases under the rule we have given.

MULTIPLICATION.

It is proved in arithmetic that the product of two or more numbers is the same whatever be the order in which they are multiplied; therefore if a is to be multiplied by b, it is indifferent whether we write the product ab or ba. This being regarded as a fundamental principle, we proceed to the multiplication of quantities consisting each of a single term, as $6a^2b^3$ and $4ab^2$. The product of these is $6a^2b^3 \times 4ab^2$. Now if we restore each of these terms to its original form, of which the present is merely a representation, the expression becomes $6 \times a \times a \times b \times b \times b \times 4 \times a \times b \times b$. But as the product of these terms is the same whatever be the order in which we multiply them, therefore the expression may be written $6 \times 4 \times a \times a \times a \times b \times b \times b \times b \times b$, or $6 \times 4 \times aaabbbbb$; and as 6×4, or six taken four times, is 24, this last expression is represented by $24a^3b^5$. We observe that the exponent of a in the product is the sum of the exponents of that letter in the two quantities to be multiplied, as is also that of b. Thus a^2 represents aa, which multiplied by a, is aaa, or a^3; b^3 represents bbb, and b^2, bb; whence $b^3 \times b^2$ is $bbbbb$, which is indicated by b^5. Similarly, we find the product of any two powers of the same quantity to be that quantity raised to the power denoted by the sum of the exponents of each factor contained in it. This is expressed generally by $a^m \times a^n = a^{m+n}$, m and n representing any numbers whatsoever. Therefore to multiply two quantities composed of a single term, write down every letter which occurs in either of them, giving to each for exponent the sum of the exponents of that same letter in the two quantities; to this prefix the product of the two co-efficients, and the expression obtained will be the product required.

The advantage of the extension of the notation of exponents and of co-efficients to single factors of a letter, by giving each, unity for index or co-efficient, as in representing a and b by $1a^1$ and $1b^1$, is now apparent. Had we not done so, the above rule would not have been universal.

It is evident that the number of single factors contained in the product of two monomials is equal to the sum of the number of factors contained in each of them; or the number of the dimensions of the product is equal to the sum of the dimensions of the two monomials.

Let us now proceed to the multiplication of quantities consisting of more than a single term, as a and $b + c$. The product of these is $a(b + c)$, composed of two separate expressions, which it may be necessary to reduce to a single one. To effect this, we multiply a by b, and obtain ab; this however is not enough, it is only a taken b, instead of $b + c$, times; we must therefore take it c times more, which gives us ac to be added to ab. The required product is then $ab + ac$. Again, a multiplied by $b - c$, is $a(b - c)$, which indicates that a is to be taken the number of times contained in b diminished by c. If then we take a, b times, or ab, we have taken it too often by c times; it must therefore be subtracted from that product c times, which gives the result $ab - ac$.

Let it now be proposed to multiply $a + b$ by $c + d$. Consider $c + d$ as a single term; and $(a + b)(c + d)$ becomes $a(c + d) + b(c + d)$, which, from what we have just seen, is equal to $(ac + ad) + (bc + bd)$, or

$ac + ad + bc + bd$. Also $(a - b)(c + d)$ becomes $a(c + d) - b(c + d)$, which is equal to $(ac + ad) - (bc + bd)$, or $ac + ad - bc - bd$, according to the rule for subtraction. Similarly $(a + b)(c - d)$, regarding $c - d$ as a single term, becomes $a(c - d) + b(c - d)$, which is $ac - ad + bc - bd$; and $(a - b)(c - d)$ is $a(c - d) - b(c - d)$, which is equal to $(ac - ad) - (bc - bd)$, or $ac - ad - bc + bd$.

In examining the above results, we observe that the following principles regulate the signs to be prefixed to the different terms which they contain.

When each of the two terms which compose any term in the product is preceded by $+$, the sign of that term is also $+$.

When the sign of one of the terms is $+$, and of the other $-$, that of the term which is composed of them is $+$.

When each of the terms is preceded by $-$, the sign of the term which they compose is $+$.

Hence we deduce the following rule for the multiplication of two polynomials: multiply each term of the one by each term of the other, and whenever both of the terms so multiplied have the same sign, prefix $+$ to their product; but when their signs are different, prefix $-$ to the product; and connect the partial products so obtained by their respestive signs. It is evident, that in order to render this rule applicable to the first term of the multiplicand, when that term has no sign, we must, as in the case of the operations of addition and subtraction, consider it to be preceded by $+$, as by so doing we shall obtain correct results, and include under one rule that which would otherwise require two.

A few examples will serve to render the principle upon which is deduced that portion of the rule which relates to the signs of the terms of the product, clearer and more apparent than any abstract reasonings on the nature of positive and negative terms, which, be it remembered, according to the meaning we have as yet attached to those quantities, exist only in connexion with others.

The following remarks upon the multiplication of polynomials are important to be attended to:

When all the terms of a polynomial contain the same number of dimensions, or, in other words, are of the same degree, the polynomial is said to be ***homogeneous***.

The product of two homogeneous polynomials is also homogeneous. For all the terms of the multiplicand contain by the definition of homogeneous, the same number of factors, as also do all those of the multiplier; hence, if the number of factors in any one term of the former be added to the number of factors in any one term of the latter, the sum will always be the same. But every one of the terms of the product is formed by the multiplication of a term of the multiplicand by a term of the multiplier, and the number of factors contained in it is the sum of the numbers contained in those two terms; therefore the number of factors in every term of the product is the same, being composed of the same sum, or the product is homogeneous. This circumstance affords us an easy method of detecting errors in the exponents of letters in the multiplication of homogeneous polynomials. For instance, if one of the terms of the product has 6 dimensions, and all the others 7, it is a manifest indication of a mistake having been committed in the addition of the exponents.

If the product obtained by the multiplication of any two polynomials be unsusceptible of reduction, then the number of terms contained in it is equal to the product of the number of terms in the multiplicand, multiplied by the number of those in the multiplier. This is an evident consequence of the nature of the multiplication of polynomials. If, however, the product be capable of being reduced, then, of course, when that operation has been performed, the number of its terms is less. But there are always two of its terms which never can be reduced by incorporation with any others, namely: 1°, the term resulting from the multiplication of that term of the multiplicand which contains the highest power of one of the letters, by that term of the multiplier which contains the highest power of the same letter; 2°, the term resulting from the multiplication of the two terms containing the lowest powers of the same letter in the multiplicand and multiplier. For these products must contain a power of that letter higher and lower than any other partial products, which consequently cannot be ***like terms*** in regard to them.

As the operations of algebra are effected on letters which represent no particular numbers, and which consequently may be made to stand for any, their results must be true for all numbers whatsoever; and as the nature of those operations allow us to perceive how their results are constituted, and to observe the different portions of the quantities operated on which enter into their composition, we are enabled to ascertain certain general properties of numbers which are independent of any system of numeration. The following are remarkable exemplifications of this observation, and in the form we have given them will be useful exercises.

It is required to prove

1°. That

$$(a + b)(a + b) = a^2 + 2ab + b^2;$$

or, that the square of the sum of two quantities is equal to the square of the first quantity, plus the square of the second, plus twice the product of the first and second.

2°. That

$$(a - b)(a - b) = a^2 - 2ab + b^2;$$

or, that the square of the difference of two quantities is equal to the square of the first, plus the square of the second, minus twice the product of the first and second.

3°. That

$$(a + b)(a - b) = a^2 - b^2;$$

or, that the product of the sum and difference of two quantities is equal to the difference of their squares.

These examples are of very frequent occurrence in algebra, and their results should be well remembered, as, by employing them in combination, we are enabled in certain cases to find the product of polynomials more expeditiously than by the ordinary method. Thus if $3a^2 - 5b + 2ab$ is to be multiplied by $3a^2 - 5b - 2ab$, we observe that the former of these expressions is the sum of $3a^2 - 5b$ and $2ab$, and the latter their difference; therefore their product should be equal, by (3°), to $(3a^2 - 5b)^2 - (2ab)^2$, which by (1°) is equal to $9a^4 - 30a^2b + 25b^2 - 4a^2b^2$.

Division.

In algebra, as in arithmetic, the operation of division is the reverse of that of multiplication. In the performance of multiplication, our object is to find a quantity which shall contain another quantity a certain number of times; in that of division, it is to

ascertain how many times one quantity is contained in, or can be subtracted from, another. In the one case, the two factors are given, and the product is required; in the other, the product and one of the factors is given, and the remaining factor is required.

Let us suppose that $36a^4$ is to be divided by $4a^2$, which is indicated by $\frac{36a^4}{4a^2}$. To effect this division, it is required to find a third quantity, which multiplied by $4a^2$, shall produce $36a^4$. According to the rule laid down for the multiplication of monomials, this quantity must be such, that its co-efficient multiplied by 4, may give 36, and that the exponent of the letter a in it, added to 2, the exponent of the letter a in the divisor, may be equal to 4, the exponent of that same letter in the dividend. The co-efficient of this required quantity must then be 36 divided by 4, or 9, and its exponent, $4-2$, or 2; and the quantity itself therefore $9a^2$. Similarly,

$$\frac{15a^5\,b^3\,c}{3a^3\,b}=\frac{15}{3}a^{5-3}\,b^{3-1}\,c=5a^2\,b^2\,c.$$

Hence, to effect the division of monomials, divide the co-efficient of the dividend by that of the divisor; subtract the exponent of each letter in the former from that of the same letter in the latter, and the remainder will be the exponent of that letter in the quotient; and write after the result thus obtained, all the letters which enter only into the dividend, and not into the divisor, preserving to each its particular exponent.

If we apply this rule to the division of such expressions as a^4 by a^4, in which the letter has the same exponent in the dividend and the divisor, since 4 subtracted from 4 leaves 0, the result is a^0, a new symbol to which we have as yet attached no meaning. In order to ascertain what signification we ought to attach to such an expression, we recur to its origin, and find that it is the result of an operation performed cccording to a certain rule upon a particular case, for which that rule was never intended, and to which if we apply the common principles of division, we shall obtain unity for result. For by the nature of division, a^4 divided by a^4, is 1; that is to say, the number of times which a^4 contains a^4 is one. Therefore as a^0 is an unintelligible result which has no signification, we agree that it shall represent the intelligible result obtained by the performance in a different manner of the same operation by which it is itself produced. Hence we say that

$$a^0=1.$$

Whenever, therefore, in the solution of a question we meet with a letter which has 0 for exponent, we may consider it as an indication that we have in a previous stage of the investigation divided a power of that letter by itself according to the common rule, and have neglected to remark that the quotient is 1, which we ought therefore now to substitute for the symbol which we then adopted in its place. The advantage which we derive from the employment of this symbol in this conventional signification is, that it enables us to retain in our calculations, as is frequently necessary, the trace of a letter which entered into the original expression of the question to which they relate, but which has since disappeared through the performance of a division; and this without at the same time in the slighest degree affecting the result of those calculations.

It is evident, from the above rule, that the concurrence of three conditions is necessary in order that the division of monomials may be possible:—1°, that the co-efficient of the dividend should be divisible by that of the divisor; 2°, that there should be no higher powers of any letters in the divisor than those of the same letters in the dividend; 3°, that no letter should enter into the divisor which does not also enter into the dividend. If any single one of these conditions be not fulfilled, the quotient can only be obtained under the form of a *fractional monomial*, that is, a monomial which cannot be expressed without employing the sign of division, but which can frequently be simplified.

Thus suppose that $6a^3b^2cd$ is to be divided by $4a^2bc^2$. In the first place the co-efficient 6 is not divisible exactly by the co-efficient 4; and secondly, there is a higher power of c in the divisor than in the dividend, therefore we can only obtain the quotient under the form of $\frac{6a^3b^2cd}{4a^2bc^2}$. But as both the dividend and divisor contain the common factors 2, a^2, b, and c, the quotient will not be affected by striking those factors out of each, and it will then become $\frac{3abd}{2c}$. We may satisfy ourselves of the correctness of the result we have obtained in multiplying it by the divisor, when it ought to produce the dividend. Thus $\frac{3abd}{2c}\times 4a^2bc^2$ is $3abd$, divided by $2c$, and multiplied by $2c\times 2a^2bc$, which is equivalent to $4a^2bc^2$; or as $3abd$, first divided by $2c$, and then multiplied by the same quantity, is evidently but $3abd$; the product is equal to $3abd\times 2a^2bc$, or to $6a^3b^2cd$.

Hence when the division of two monomials is impossible, indicate the performance of the operation by writing the divisor below the dividend with a line between them, in the form of a fraction; strike out the greatest common factor of the two co-efficients, subtract the exponent of the lower power of every letter which is common to both the dividend and divisor from that of the higher power of the same letter, and write that letter with the difference for its exponent in the term of the fraction to which the higher power belongs. The expression which remains after these operations have been performed, will be the most simple form in which we can obtain the quotient. According to this rule it will be be found that

$$\frac{48a^3\,b^2\,cd^3}{36a^2\,b^3\,c^2\,de}=\frac{4ad^2}{3bce}$$

$$\text{And }\frac{37ab^3c^5d}{6a^3\,bc^4\,d^2}=\frac{37b^2c}{6a^2d}$$

The division of polynomials is more complicated than that of monomials, and the principles in which it is performed may be illustrated in the following manner: Let A represent an expression which is to be divided by N, and Q, the quotient of the two. If the operation can be performed without any remainder, then $A=QN$, for by the nature of division the quotient is an expression which when multiplied by the divisor, will give the dividend. Suppose A to consist of several terms, and to be equal to $a-b+c+d$, then restating our equation, we have

(1.) $A=QN$.

(2.) $Q=a-b+c+d$.

Substituting for Q in (1.) its equivalent in (2.)

$$A = (a - b + c + d)\ N.$$

(3.) $$= aN - bN + cN + dN.$$

Suppose that we have found the first term a of the quotient; then, as N which is the divisor is known, aN is also known. Subtract this last term from the equal quantities A and $aN - bN + cN + dN$; the remainders will of course be equal, or

$$A - aN = - bN + cN + dN.$$

(4.) $$= (- b + c + d)\ N.$$

Now $A - aN$ is the remainder which is obtained by multiplying the term of the quotient a, which we have found by the divisor N, and subtracting the product from A. For the sake of convenience, call this remainder B; then

(5.) $$B = (- b + c + d)\ N.$$

or, if B be regarded as a dividend, and N still continue the divisor, $(- b + c + d)$ will be the quotient, which is all the first quotient with the exception of the part of it which we have found. Let us proceed with this new dividend as with the first one; that is, suppose that we have by some means found b, and that its sign in the quotient is —; we therefore have bN. Add this latter expression to both of the equal quantities B and $(- b + c + d)$ N, and the sums will be equal; or

$$B + bN = - bN + cN + dN + bN = cN + dN.$$

Let $B + bN$ be represented by C; then

(6.) $$C = cN + dN = (c + d)\ N$$

Again, if C be made a dividend, and N remain the divisor, the quotient is $c + d$, or all the last quotient except the part of it which we have found. We proceed as above, and find c, and therefore cN; subtracting this latter from the equal quantities C and $cN + dN$, representing $C - cN$ by D, we have

$$D = dN,$$

making D a fresh dividend, and keeping N for divisor.

Suppose that we have found d; subtracting dN from the equal quantities D and dN, we have

(7.) $$D - dN = 0,$$

or the remainder is equal to nothing. This indicates that we have now obtained all the terms of the required quotient, and that the process is completed.

If we now collect together the different terms of quotients which we have found, prefixing to each its proper sign, the result will be the quotient of A divided by N. For we have seen that the quotient of B by N is the same as all the quotient of A by N with the exception of a. Or

$$\frac{A}{N} = \frac{B}{N} + a$$

And similarly,

$$\frac{B}{N} = \frac{C}{N} + b$$

$$\frac{C}{N} = \frac{D}{N} + c$$

$$\frac{D}{N} = \frac{0}{N} + d$$

Or substituting the different values for one another,

$$\frac{A}{N} = \frac{C}{N} + a + b$$

$$= \frac{D}{N} + a + b + c$$

$$= \frac{0}{N} + a + b + c + d$$

$$= a + b + c + d.$$

We will now proceed to the application of these principles to an example in which the letters we have employed are replaced by particular expressions; as the division of $18x^2y^2 - 8x^3y + 2x^4 - y^4 - 11xy^3$, which call A by $x - y$ or N.

In our remarks on multiplication, we observed that the term which contains the highest power of any letter in a product is wholly made up of the product of the two terms containing the highest power of the same letter in the multiplier and multiplicand. Therefore as the expression A is the product of N and the required quotient, if we divide the highest power of any letter in A as $2x^4$ by x, the highest power of the same letter in N, the result $2x^3$ will be one of the terms of the quotient. In order to give a connected view of the different steps, we here insert the whole operation, accompanying each line with the corresponding step in our first process.

		(N)	(A)	(a)
		$x - y$)	$18x^2y^2 - 8x^3y + 2x^4 - 4y^4 - 11xy^3$	$(2x^3$
(a N.)	Subtract		$2x^4 \quad - 2x^3y$	
				(b)
(B.)	Second dividend		$18x^2y^2 - 6x^3y - y^4 - 11xy^3$	$(- 6x^2y$
(b N.)	Subtract		$-6x^3y + 6x^2y^2$	
				(c)
(C.)	Third dividend		$12x^2y^2 - y^4 - 11xy^3$	$(+ 12xy^2$
(c N.)	Subtract		$12x^2y^2 - 12xy^3$	
				(d)
(D.)	Fourth dividend		$- y^4 \quad + xy^3$	$(+ y^3$
(d N.)	Subtract		$+ xy^3 - y^4$	
			0	

Hence the whole quotient is $2x^3 - 6x^2y + 12xy^2 + y^3$.

After having found $2x^3$, one of the terms of the quotient, we multiply it by the division $x - y$, and subtract the product from the whole expression A. We then obtain a new dividend B, which differs only from the former in this, that it has one term less in the quotient, namely, that term which we have found. Considering B then as the product of the divisor N and the quotient, we shall by dividing the term with the highest power of x in B, by the term with the highest power of x in N, obtain one of the terms of that quotient. But the highest power of x in B, viz. $6x^3y$ has the negative sign placed before it; therefore what sign must we prefix to the quotient which results from dividing by x? We de-

termine this from the rule deduced for the signs of the terms of a product in multiplication. For as by that rule the product of two terms which have the same sign is preceded by +, and of two which different signs by —; it follows, 1°. That if a term of the dividend have the sign + and a term of the divisor +, the term of the quotient of those two must also have +; 2°. That if the term of the dividend have the sign +, and of the divisor —, the term of their quotient must be preceded by —, in order that when multiplied by the term of the divisor which has — also, their product in the dividend may be preceded by +; 3°. That if the term of the dividend has the sign —, and that of the divisor +, the sign of their quotient must be —; 4°, and lastly, that if the term of the dividend has the sign —, and that of the divisor —, their quotient must be preceded by +. These may all be reduced to the following rule:

If the term of the dividend and that of the divisor have the same sign, their quotient must be preceded by the sign +; but if they have different signs, the sign of their quotient must be —; a term which has no sign, being considered, as in multiplication, to be preceded by +.

To resume, if we divide $6x^3y$ by x, we obtain $6x^2y$, to which must be prefixed the negative sign, when it is connected with the other terms of the quotient. We then subtract the product of this term of the quotient multiplied by the divisor N, from the whole expression B, and considering the remainder as a third dividend C, which differs only from the second in having one term less in the quotient, we operate upon it as upon the two former. We thus obtain a term of its quotient $12xy^2$; and regarding the remainder which results from the subtraction of its product by N from the whole of C, as a fourth dividend D, we find a term of its quotient, y^3; subtracting the product of this by N from D, the remainder which we obtain is nothing; thus indicating that the operation is finished.

In examining the preceeding operation, we perceive that in operating upon each dividend, we are obliged to find out the term in it which contains the highest power of x in order to divide it by the term of the divisor containing the highest power of the same letter. It is evident then that we should avoid the necessity of this search, if we previously wrote each of those expressions with the term containing the highest power of x first, the highest power but one, second, the next, third, and so on, arranging it as it is called in descending powers of x. By this means we are enabled always to know where to look for the highest power of the letter, in powers of which the expression is arranged both in the dividend and divisor. In the example which we have given, the letter x enters but into one term in the divisor, but in more complicated expressions where it occurs frequently, the full advantage of this arrangement is felt as well as in the dividend. Hence, to divide one polynomial by another, arrange both the divisor and dividend in powers of the same letter; divide the first term in the dividend by the first term in the divisor, and the result will be the first term of the required quotient; multiply the whole divisor by this term, and subtract the product from the whole dividend. Then divide the first term of the remainder by the first term of the divisor, and the result will be the second term of the quotient; multiply this term by the divisor, and subtract the product from the first remainder. Repeat this operation until the remainder obtained is 0, in which case the division is complete. The sign of each term is determined according to the rule we have already given on that point.

When the first term of a dividend arranged in powers of any letter is not exactly divisible by the first term of a divisor arranged in powers of the same letter, it is an indication that the complete division of the whole expression is impossible; that is to say, there is no polynomial which multiplied by the divisor will give the dividend; or the division is impossible when the first term of any one of the partial dividends is not divisible by the first term of the divisor.

It is evident that there is no objection to commencing by dividing the term of the dividend which contains the lowest powers of any letter by that containing the lowest power of the same letter in the divisor; for the term containing the *lowest* power of any letter in a product is also made up of nothing but the product of the two terms containing the lowest powers of the same letter in the multiplicand and multiplier. In so doing we might still arrange the divisor and dividend in descending powers of one of the letters, and commence with the last instead of the first, or adopt the method of writing them in the contrary order with the lowest powers first, the lowest but one next, and so on, arranging them as it is called in ascending powers of that letter.

The various partial operations of which every division is composed according the above rule, as we have shown, are perfectly distinct operations. We find one term of the quotient, and by the subtraction of the product of that term by the divisor from the dividend, we obtain a new dividend, the quotient of which by the same divisor is, as we have proved, all the quotient we are in search of, except the one term which we have found. We do not however find this second quotient, and add it to the term already obtained of the first, by which means we should get the whole quotient required; but we find only one term of it, and subtracting its product by the divisor from the second dividend, we operate upon the remainder as a fresh dividend, and continue so on until we obtain a dividend equal to nothing. So perfectly independent of each other are the partial operations we perform on these dividends, that we might arrange any one of them in powers of a different letter, if we arranged the divisor in a similar manner; the term we should obtain by dividing the first term in it, by the first in the divisor, would be one of the terms of the quotient.

It may happen that either the dividend or the divisor, or both of them, may have several terms, each of which contains the same power of the letter in powers of which we wish to arrange them. Thus, suppose that

$24a^2b - 24abc + 12ab^2 - 6a^2c - 8b^2c + 8bc^2 + 9a^3$

is to be divided by $3a^2 + 6ab - 4bc$;

if we proceed to arrange the dividend in powers of a, we find that $24a^2b$ and $6a^2c$ both contain the same power of that letter; we may evidently write them thus, $(24b - 6c)\, a^2$, but it is much more convenient to dispose of them in the following form:

$$\begin{array}{r|l} 24b & a^2 \\ -6c & \end{array}$$

that is, writing a^2 only once to the right of a vertical line, to the left of which are placed in the same column the remaining portions of all the several terms which contained that power of a; this assemblage of quantities to the left of the line is by an extension of

the definition considered as the co-efficient of a^2. Similarly, $24abc$ and $12ab^2$ is written

$$\begin{array}{r|l} 12b^2 & a \\ -24bc & \end{array}$$

and the whole arrangement with the operation performed,

$$\begin{array}{r|l|l} 9a^3+24b & a^2+12b^2 & a-8b^2c+8bc^2 \\ -6c & -24bc & \\ \hline 6b & a^2+12b^2 & a-8b^2c+8bc^2 \\ -6c & -12bc & \\ \hline \end{array} \left\} \begin{array}{l} 3a^2+6ab-4bc \\ \hline 3a+2b-2c \end{array} \right.$$

$$-6ca^2-12bc\,a+8bc^2$$

In this operation we have adopted the contracted method of subtracting immediately from the dividend the partial product of each term of the divisor by that of the quotient, as soon as that product is formed, and of writing down only the remainder. We have also disposed the divisor in a different, and much more convenient manner, than before; for as each term of the quotient is found, it is placed beneath the divisor, so as greatly to facilitate the multiplication of the two. In order to investigate the general principle of a case of the nature of the preceding, which is the most complicated in division, let the dividend be denoted by $Aa^4+Ba^3+Ca^2+Da+E$, and the divisor by $A'a^2+B'a+C'$, in which A, B, C, D, E, A′ B′ and C′ represent the respective co-efficients (using this word in the extended definition we have just given) of the various letters to which they are attached. Then since the highest exponent of a in the dividend is 4, and in the divisor 2, it will be 2 in the quotient, which must be of the form of $A''a^2+B''a+C''$. The portion Aa^4, containing the highest power of a in the dividend, is the unreduced result of the multiplication of $A'a^2$ and $A''a^2$, which are the highest powers of the same letter in the divisor and quotient; therefore, to find the portion $A''a^2$ of the quotient, it is only necessary to divide Aa^4 by $A'a^2$, which since a^4, divided by a a^2, is a^2, is the same as dividing A by A′, and then multiplying the result by a^2. The polynomials A and A′, must then themselves be arranged in powers of some letters which they contain; and the former being divided by the latter, we shall obtain A″, and consequently $A''a^2$, or the assemblage of all those terms of the quotient which contain the highest power of a. This separate division having been performed, we return to the principal operation, and multiplying the divisor by $A''a^2$, we subtract the product from the dividend A, and proceed with the remainder as with the original dividend, and so on. The following is an example of this nature, to which we have attached the partial divisions induced by the principal operation:—

$$\begin{array}{r|l|l|l} -12b^2 & a^3+23b^3 & a^2+10b^4 & a \\ -29bc & -31b^2c & -6b^2c^2 & \\ +15c^2 & -9bc^2 & & \\ & +15c^3 & & \\ \hline & +15b^3 & a^2+10b^4 & a \\ & -25b^2c & -6b^2c^2 & \\ & -9bc^2 & & \\ & +15c^3 & & \\ \hline \end{array} \left\} \begin{array}{r|l|l} 3b & a+2b^2 & \\ -5c & & \\ \hline 4b & a^2+5b^2 & a \\ -3c & -3c^2 & \end{array} \right.$$

$$0$$

First Partial Division.

$$\text{(A)}\ \begin{array}{r} 12b^2+29bc-15c^2 \\ \hline -9bc+15c^2 \\ \hline 0 \end{array} \left\} \begin{array}{l} 3b-5c\ \text{(A′)} \\ \hline 4b-3c\ \text{(A″)} \end{array} \right.$$

Second Partial Division.

$$\text{(B)}\ \begin{array}{r} 15b^3-25b^2c-9bc^2+15c^3 \\ \hline -9bc^2-15c^3 \\ \hline 0 \end{array} \left\} \begin{array}{l} 3b-5c\ \text{(A′)} \\ \hline 5b^2-3c^2\ \text{(B″)} \end{array} \right.$$

Under the head of *Division* we shall give a few examples of that operation which are of remarkable application, and of very frequent use in the solution of questions. For a continuation of the subject of Algebra, see *Measure, greatest common; Equations, of the First Degree; Negative Sign; Equations, of the Second Degree; Indeterminate Analysis; Permutations and Combinations; Binomial Theorem; Powers, Formation of; Roots, Extraction of; Surds; Negative Exponents; Fractional Exponents; Series; Proportions; Progressions; Logarithms; Interest and Annuities; Logarithmic and Exponential Series; Equations, Theory of,* &c. in the order we have enumerated them.

Algol or Medusa's head, in *Astronomy*, a fixed star of the third magnitude in the constellation Perseus.

Algorab, a fixed star of the third magnitude in the right wing of the constellation Corvas.

Aliment; a term which includes every thing serving as nutriment for organized beings. In animals and vegetables we can observe the phenomena of decomposition and reproduction, and analyze the substances that administer to their growth and repair distinctly. Generally, however, the word aliment is used for what serves as nutriment to animal life. It is, in this respect, a subject of great interest for the zoologist. In the present article we shall confine ourselves to the aliment of mankind. Man, it is well known, derives nourishment both from animal and vegetable substances. He eats fruits, both ripe and unripe, roots, leaves, flowers, and even the pith and the bark of different plants, many different parts of animals, and the whole of some. Climate, custom, religion, the different degrees of want and of civilization, give rise to an innumerable diversity of food and drink, from the repast of the cannibal savage of New Zealand to that of the Parisian epicure at the table of Verrey; from the diet of the carnivorous native of the north to that of the Brahmin, whose appetite is satisfied with vegetables; from the oak-bark bread of the Norwegian peasant to the luxuriously-served table of a Hungarian magnate at Vienna. Some nations abhor what others relish, and great want often renders acceptable what, under other circumstances, would have excited the greatest disgust. The flesh of dogs is commonly eaten in China, and in Africa that of snakes, particularly of the rattlesnake and boa-constrictor. Locusts are eaten both in Asia and Africa, and the Negroes on the coast of Guinea relish lizards, mice, rats, snakes, caterpillars, and other reptiles and worms. The Otomacs, a tribe of American Indians, are said by Humboldt to collect a kind of clay to eat in the rainy season. It is an interesting subject, by no means sufficiently investigated as yet, how far the different aliment of various countries is connected with the climate, &c., and what influence it exerts on the different races, as well as the consequences of introducing new species of aliments. Some excellent remarks on the national dishes of different nations were published by Baron Rumor, a German, in 1822, in a work which he called *Kochkunst* (Art of Cookery). All kinds of aliment must contain nutritious substance, which being

extracted by the act of digestion, enters the blood, and effects by assimilation the repair of the body. (See NUTRITION.) Alimentary matter, therefore, must be similar to animal substance, or transmutable into such. In this respect, alimentary substances differ from medicines, because the latter retain their peculiar qualities in spite of the organs of digestion, and will not assimilate with the animal substance, but act as foreign substances, serving to excite the activity of particular organs or systems of the body. All alimentary substances must therefore be composed in a greater or less degree, of soluble parts, which easily lose their peculiar qualities in the process of digestion, and correspond to the elements of the body. These substances, in their simple state, are mucilage, gelatin, gluten, albumen, farina, fibrin, and saccharine matter. Of these, vegetables contain chiefly mucilage, saccharine matter, and farina, which latter substance, particularly in connexion with the vegetable gluten, by which both become apt for fermentation, and thus for dissolution and digestion, is the basis of very nutritious food. The nutritive part of fruits consists of their saccharine matter and a little mucilage. In animal food, gelatin is particularly abundant. The nutritiousness of the different species of food and drink depends, therefore, upon the proportion which they contain of those substances, and the mode in which they are connected, favouring or obstructing their dissolution. Organs of digestion in a healthy state dissolve alimentary substances more easily, and take up the nutritious portions more abundantly, than those of which the strength has been impaired so that they cannot resist the tendency of each substance to its peculiar chemical decomposition. The wholesome or unwholesome character of any aliment depends, therefore, in a great measure, on the state of the digestive organs, in any given case. Sometimes a particular kind of food is called wholesome, because it produced a beneficial effect of a particular character on the system of an individual. In this case, however, it is to be considered as a medicine, and can be called wholesome only for those whose systems are in the same condition. Very often a simple aliment is made indigestible by artificial cookery. Aliments abounding in fat are unwholesome, because fat resists the operation of the gastric juice. The addition of too much spice makes many an innocent aliment injurious, because spices resist the action of the digestive organs, and produce an irritation of particular parts of the system. They were introduced as artificial stimulants of appetite. In any given case, the digestive power of the individual is to be considered, in order to determine whether a particular aliment is wholesome or not. In general, therefore, we can only say, that that aliment is healthy, which is easily soluble, and is suited to the power of digestion of the individual; and, in order to render the aliment perfect, the nutritious parts must be mixed up with a certain quantity of innocent substance affording no nourishment to fill the stomach, because there is no doubt that many people injure their health by taking too much nutritious food. In this case, the nutritious parts which cannot be dissolved act precisely like food which is in itself indigestible. (See DIGESTION.) In Prussia and Austria, where, as in many despotic governments, the medical police is very good (this being a thing much more easily regulated in an absolute government than in a free one), the public officers pay much attention to aliment, and are careful that provisions exposed to sale shall be of a good quality, particularly that no decayed or adulterated things are sold to the poor. Such regulations exist, to a certain extent, in England, France, the United States of America, and in fact in every civilized country. The kind of aliment used, influences the health and even the character of man. He is fitted to derive nourishment both from animal and vegetable aliment, but can live exclusively on neither. Experience proves that animal food most readily augments the solid parts of the blood, the fibrin, and therefore the strength of the muscular system, but disposes the body at the same time to inflammatory, putrid, and scorbutic diseases, and the character to violence and coarseness. On the contrary, vegetable food renders the blood lighter and more liquid, but forms weak fibres, disposes the system to the diseases which spring from feebleness, and tends to produce a gentle character. Something of the same difference of moral effect results from the use of strong or light wines. But the reader must not infer that meat is indispensable for the support of the bodily strength. The peasants of some parts of Switzerland, who hardly ever taste any thing but bread, cheese, and butter, are vigorous people. The nations of the north incline generally more to animal aliment; those of the south, and the Orientals, more to vegetable. The latter are generally simpler in their diet than the former, when their taste has not been corrupted by luxurious indulgence. Some tribes in the East, and the caste of Brahmins in India, live entirely on vegetable food. The inhabitants of the most northern regions live almost entirely upon animal food, scarcely ever partaking of any vegetable substance, at least during the greater part of the year. Some nations feed chiefly on terrestrial animals, others on aquatic ones.

ALIMENTARY CANAL, in *Anatomy*, the whole tract of intestines, including the stomach.

ALIMENTARY DUCT, the same as the thoracic duct.

ALKAHEST, or ALCHAHEST, in *Chemistry*, a name first used by Paracelsus, by whom it was probably coined to signify an universal menstrum. It is explained by Van Helmont to signify a salt of the highest sort, that had attained to the highest state of purity and subtilty. It was supposed to possess the virtue of pervading every substance; and while it acted on every thing else, it remained itself immutable.

ALKALI, in *Chemistry;* from the Arabian *kali*, the name of a plant from the ashes of which one species of alkali can be extracted. The substances that are met with under the denomination of alkaline, are possessed of certain peculiar properties; they are mainly characterized, however, by a power of combining with acids in such a manner as to impair the activity of the latter, so that alkalies, as chemical agents, are distinguished by properties the reverse of acids; acids and alkalies are, therefore, generally considered as antagonist substances. Besides the power of neutralizing acids, and thereby forming certain saline substances, the alkalies are further distinguished by the following properties:—1, they have an acrid taste and corrosive power when applied to some substances, thus proving caustic to the skin and tongue; 2, they change vegetable blue to green, red to purple, and yellow to a reddish brown (if the purple be reddened by an acid, an alkali will restore the original colour); 3, they are almost indefinitely soluble in water; that is, they combine with it in every proportion; 4, they unite with oils and fats, and form by this union the

well-known compound called *soap*. There is another class of substances which have a strong analogy with alkalies, especially in the particular of opposition to acids, viz. the earths. Some of these, indeed, have been classed by Fourcroy among the alkalies, but they have been kept separate by others, on the ground that the analogy between them is far from amounting to an identity of properties. The true alkalies have been arranged by a modern chemist in three classes:—1°, those which consist of a metallic basis, combined with oxygen; these are 3 in number—potash, soda, and lithia; 2°, that which contains no oxygen, viz. ammonia; 3°, those containing oxygen, hydrogen, and carbon; in this class are placed aconita, atropia, brucia, circuta, datura, delphia, hyoscyamia, morphia, strychina. It is supposed that the vegetable alkalies may be found to be as numerous as the vegetable acids. The original distribution of alkaline substances was into volatile and fixed, the volatile alkali being known under the name of *ammonia;* while, of the two fixed kinds, one was called *potash* or *vegetable*, because procured from the ashes of vegetables generally; the other, *soda* or *mineral*, on account of its having been principally obtained from the incineration of marine plants.

Allegro, in *music;* a word denoting one of the six distinctions of time. It expresses a sprightly motion, the quickest of all, and originally means gay. The usual distinctions succeed each other in the following order—*grave, adagio, largo, vivace, allegro, presto*. Allegro time may be heightened, as *allegro assai* and *allegrissimo*, very lively; or lessened, as *allegretto* or *poco allegro*, a little lively. *Più allegro* is a direction to play or sing a little quicker.

Alloy; a composition, the result of a mutual combination of two or more metals. To alloy generally means to mix a metal of less with one of more value. Various processes are adopted in the formation of alloys, depending upon the nature of the metals. Many are prepared by simply fusing the two metals in a covered crucible. It has been a question whether alloys are to be considered as compounds, or as mere mixtures. Mr. Dalton considers alloys to be chemical compounds, one striking instance of which is in the alloy of tin and copper, called *speculum metal;* the smallest deviations from the true proportions will spoil the alloy as a reflector. In some cases, the metals are found to unite in definite proportions only; and it is probable that all the alloys contain a definite compound of the two metals. The principal characters of the alloys are the following:—1. We observe a change in the ductility, malleability, hardness, and colour. Malleability and ductility are usually impaired, and often in a remarkable degree; thus gold and lead, and gold and tin, form a brittle alloy. The alloy of copper and gold is harder than either of its component parts; and a minute quantity of arsenic added to copper renders it white. 2. The specific gravity of an alloy is rarely the mean of its component parts; in some cases an increase, in others a dimunition of density having taken place. 3. The fusibility of an alloy is generally greater than that of its components. Thus platinum, which is infusible in our common furnaces, forms, when combined with arsenic, a very fusible alloy; and an alloy of certain proportions of lead, tin, and bismuth is fusible at 212°; a temperature several degrees below the melting point of its most fusible constituent. 4. Alloys are generally more oxydizable than their constituents taken singly; a property which is, perhaps, partly referable to the formation of an electrical combination. From early times, the baser metals have been used to alloy gold and silver coins, to prevent loss by wear. In England, the legal proportion of base metal for gold coin is 1 part in 12, and for silver coin 3 parts in 40. In France the legal proportions of the different coins are as follow: silver coin, 9 parts silver, 1 copper; copper money, 4 parts copper, 1 silver; gold coin, 9 parts gold, 1 copper. For silver plate, the French proportions are 9½ parts silver, ½ copper; for trinkets, 8 parts silver, 2 copper. For gold plate they have three different standards; 92 parts gold, 8 copper; also, 84 gold, 16 copper, and 75 gold, 25 copper. Gold and silver are alloyed partly that they may wear better, partly to diminish the price of articles made of them.

Almacantor. A name for the parallels of altitude on the celestial globe, whose zenith is the pole or vertical point.

Almond, a Portuguese measure of oil, equal to four gallons and a half.

Almond, in *Anatomy*, a name for the glandular substances on each side of the uvula at the root of the tongue, otherwise called *tonsillæ*.

Altitude denotes the perpendicular height of the vertex of any plane or solid body, above the line or plane of its base; thus the altitude of a triangle is measured by a perpendicular let fall from any one of its angles upon the base, or upon the base produced; therefore the same triangle may have different altitudes, accordingly as we assume one side or another for its base. Again, the altitude of a cone or pyramid, whether right or oblique, is measured by a perpendicular let fall from the vertex to the plane of its base. Similar remarks apply to other solids. In astronomy, altitudes are measured or estimated by the angles subtended between the object and the plane of the horizon; and this altitude may be either *true* or *apparent*. The *apparent* altitude is that which is obtained immediately from observation; and the *true* altitude that which results from correcting the apparent altitude, by making allowance for parallax, refraction, &c. The altitude of a terrestrial object is the height of its vertex above some horizontal plane assumed as a base. The altitude of mountains is measured generally from the level of the ocean; that is, the altitude of a mountain is the difference between the mean terrestrial radius, and the distance of the vertex of the mountain from the centre of the earth. If the altitude of a mountain is given without any explanation, the altitude above the ocean is always understood. This altitude can be measured trigonometrically, by barometrical observations, or by actually measuring the level between the base and vertex of an object; and, if very great accuracy is not required, by optical reflection, by the length of shadows, moveable staves, the geometrical square, &c.; and, generally, by any method in which the calculation depends upon the similarity of plane rectilinear triangles.

Alto, or Alto Tenore. *Alto* is the term applied to that part of the great vocal scale which lies between the *mezzo soprano* and the tenor, and which is assigned to the highest natural adult male voice. In scores it always signifies the counter-tenor part.

Alum, *artificial*. Common alum is a triple salt, consisting of sulphuric acid, alumine, potash, and water, or of sulphate of alumine, and sulphate of pot-

ash, united together with a certain quantity of water of crystallization. It crystallizes in regular octahedrons, which are generally truncated on their edges and solid angles. Alum may also be formed by substituting either soda, ammonia, or magnesia for the potash, without at all altering its crystalline form or its taste. It dissolves in 5 parts of water, at 60°, and the solution reddens vegetable blues, indicating the excess of acid which this salt contains. Exposed to heat, it undergoes a watery fusion, and becomes light and spongy, in which condition it possesses slightly corrosive properties, and is used as a caustic, under the name of *alumen exsiccatum*. The simplest process by which alum is prepared is, perhaps, that adopted at the Solfatara near Naples, which is covered with a white clayey soil, through which sulphureous vapours are constantly emitted. This soil is always hot, and nothing more is requisite than to immerse into it cisterns, and subject the earthy matter to lixiviation; after which, the saline solution is evaporated by means of the subterranean heat also, and placed in a situation to cool, when the alum is deposited in crystals. As nothing is added during the process, it is obvious that the alum must exist ready formed in the soil. From the presence of a small portion of iron, the Solfatara alum is not so valuable, for many purposes, as that produced elsewhere; and accordingly its use is mostly confined to the Neapolitan states. The manufacture of alum directly from its component parts has of late years furnished a large proportion of this substance found in commerce. The process is conducted in the following manner: sulphur and nitrate of potash (nitre) are mixed together, in the proportions for forming sulphuric acid, and brought into combustion in large leaden chambers, or rooms lined with a thick coating of plaster. The sulphur is thus acidified and converted into vapour, and the floor of the apartment being covered with clay of the purest kind, previously calcined, the acid gradually combines with it, and forms sulphate of alumine, which after a few days is dissolved out and considerably reduced by evaporation, when a solution of sulphate of potash (being the residue of the combustion of the nitre and sulphur) is poured in, and the perfect crystals of alum are deposited. The importance of alum in the arts is very great, and its annual consumption is immense. It is employed to increase the hardness of tallow, to remove greasiness from printers' cushions, and blocks in calico manufactories, and to render turbid waters limpid. In dyeing, it is used to cleanse and open the pores on the surface of the substance to be dyed, and by the attraction of the colouring matter for the alumine it contains, to render it fit for receiving the colouring particles. Wood and paper are dipped into a solution of it to render them less combustible. Paper impregnated with alum is useful in whitening silver, and in silvering brass without heat. It is also largely used in the composition of crayons, in tannery, and in medicine.

The discovery of alum is entirely unknown; all attempts to trace the origin of its manufacture have been quite unsuccessful. In the middle ages, alum-works existed at Rocca in Syria, since called Edessa, whence probably the commercial name of rock-alum, at Foya Nova, near Smyrna, and in the vicinity of Constantinople. From these places the Genoese, and other commercial states of Italy, procured the alum with which they supplied the western and northern parts of Europe. About the middle of the fifteenth century this manufacture was introduced into Italy, and the establishments of La Tolfa, Viterbo, and Volaterra, soon acquired an importance which induced Pope Pius II. to prohibit the use of oriental alum. Early in the sixteenth century the art of preparing this salt extended to Spain and Germany. The alum-works of Whitby, in England, were established in the reign of Charles I., by Sir Thomas Chaloner; and in the seventeenth century the manufacture of alum began also to be undertaken in Sweden.

Alum was well known by the older chemists to contain an earth in combination with sulphuric acid; but from its being precipitable in a white pulpy mass by a carbonated alkali, and being again soluble with effervescence in an acid, the common opinion for a long time was that this earth was calcareous, and therefore that there was a considerable analogy between alum and selenite. Geoffroy, Barron, Hellot, and Pott, in their interesting experiments on this salt, showed that its earthy base was contained in clay; and Marggraf, in his two memoirs on this subject, made a still nearer approach to the knowledge of its constituent parts. He showed that the precipitated earth of alum, when well washed, is resoluble in sulphuric acid, even after it has been calcined, but that this solution yields on evaporation only a saline magma, instead of crystals of alum: the same effect takes place if a native clay is used, instead of the earth of alum. This able chemist also proved that the addition of a little potash to the sulphate of alumine, communicated to it the property of depositing octahedral crystals of genuine alum: he seems however to have considered the alkali only to be of use in combining with and neutralizing a certain oily or greasy matter, which by adhering to the crystalline plates of the magma, prevented them from coalescing into hard and perfect crystals. The essay of Bergman, on the preparation of alum (published first in 1767), added considerably to our knowledge of the ingredients and chemical properties of this salt: it is here shown that a small excess of acid is necessary to the constitution of alum; since, when this is taken away, its taste, solubility, and crystallizability are destroyed. The author also mentions, in the same treatise, that those lixivia, which on account of their great excess of acid cannot by mere evaporation be made to deposit alum, may be brought to a crystallizable state by the addition of potash or ammonia, but not by means of soda or lime. He further observes, that vitriolated potash and alum combine into a triple salt; yet is by no means of opinion that all alum necessarily contains either potash or ammonia; on the contrary, he recommends the acid uncrystallizable lixivia to be treated with clay, in order to neutralize their great excess of acid, and dispose them to deposit a larger quantity of crystals than could be procured from the addition of potash. This proposed improvement of the manufacture was introduced without success into some of the German establishments, and many of the chemists of that nation began to consider alum as a proper triple salt, in which the presence of potash or ammonia was absolutely necessary: Professor Hildebrand, and Klaproth, in particular, were decidedly of this opinion. It is to the accurate and indefatigable Vanquelin, however, that chemistry is indebted for the latest and most satisfactory experiments on this subject, which have

scarcely left any thing further to be known relative to the composition of this salt.

He first dissolved in pure sulphuric acid some alumine equally pure, and then evaporated the solution repeatedly to dryness, in order to drive off the excess of acid: the dry pulverulent residue being then redissolved in water, was brought by evaporation to various states of specific gravity for the purpose of crystallization; but notwithstanding every precaution, a flaky crystalline residue was all that could be procured. The solution which had thus constantly refused of itself to yield crystallized alum, began to deposit some immediately on the addition of a few drops of carbonated potash; and by accurately proportioning the alkali, the whole of the liquor to the very last drop was made to furnish by evaporation octahedral crystals of alum.

Another portion of the same pure aluminous sulphate was mixed with the same quantity of carbonated soda as had been employed of potash in the preceding experiment, but no crystals were deposited, even by evaporation. Nor were lime or barytes more efficacious. Hence it may be inferred that alum is by no means a pure sulphate of alumine, and that the use of potash in promoting its crystallization is not to saturate a supposed excess of acid. This was further demonstrated by substituting sulphate of potash and sulphate of ammonia for these alkalies in their pure or carbonated states; in which case, being already saturated with sulphuric acid, they could not possibly contribute to deprive the aluminous sulphate of a supposed excess of the same acid; yet in this case, as in the former, the uncrystallizable sulphate of alumine was made to deposit crystals of genuine alum. The same effect took place even when acidulous sulphate of potash was substituted for common sulphate of potash.

Alum, *native*, is found in most countries in the state of an efflorescence or mould upon the surface of certain slate clays and lavas, and in the United States in mica-slate rocks; also, in delicate hair-shaped fibres, occupying clefts in a bituminous shale, principally found in Italy. It may always be easily recognized by its sweetish, astringent taste, in which it resembles the artificial alum. It exists only in very limited quantities, and contains too many impurities to be of any practical use.

Alumina. This earth has neither smell nor taste while dry; it is soft to the touch, and adheres strongly to the tongue; by exposure to an intense heat it is imperfectly fused, and becomes so hard as to strike fire with steel, and to be capable of cutting glass. Its specific gravity is 2.00. It is scarcely soluble in water; but when dry, it is capable of absorbing 2½ times its weight of water, and easily mixes with a greater quantity to form a paste: it is soluble in all acids, and in solutions of caustic, potash, and soda. It is often called argil or pure clay. Alumina derives its name from alum, from which salt it is obtained in the greatest purity. Common alum is chiefly a sulphate of alumina; common clay is alumina mixed with silex, and several other bodies.

Ignition renders alumina incapable of forming a paste with water; but it recovers this property by solution and precipitation.

To obtain alumina, dissolve alum in hot water, and add ammonia or potash to the solution, as long as any precipitate is formed. Decant off the fluid, and wash the precipitate in a large quantity of water. This precipitate is alumina, combined with only a small portion of sulphuric acid, whereas, in the state of alum, it was supersaturated with the acid. If this precipitate be dissolved in muriatic acid; the solution evaporated till it deposits crystals in cooling; these crystals separated each time after repeated concentrations of the solution; and, lastly, a precipitate formed by ammonia, alumina nearly pure will be obtained; the crystals separated consisting of the alum.

Alumina cannot be artificially crystallized; but it is found native in beautiful transparent crystals, of great hardness, and of the specific gravity of 4. In this state it forms the precious stone called sapphire.

Though alumina alone is exceedingly refractory in the fire, yet it easily fuses and enters into combination with lime, for which it has a strong affinity. Alumina has also a strong affinity for metallic oxides, particularly those which contain most oxygen. The various colours of clay are mostly owing to the oxide of iron combined with them.

Alumina is of great importance to mankind; it enters largely into the composition of the best arable soils; as it swells and will not permit water to pass through it, it is inestimable as a lining for canals and reservoirs; for this purpose it is used in the state of clay; combining readily with greasy substances, it is also of the first importance in scouring cloth, to which use it is often applied in the form of pipe-clay; but, in manufactures, fuller's earth is chiefly used, which is alumina mixed with very fine silex. Clay is also extensively required for making bricks and tiles. Alumina is the base of all earthenware and porcelain, and its utility for these purposes renders it of great consequence. In one province of China, five hundred furnaces and nearly a million of men, are said to be employed in the manufacture of porcelain.

The basis of alumina is the metal aluminum, which may be obtained in the form of a grey powder, by causing potassium to act on chloride of aluminum. It burns splendidly in oxygen; and an oxide is procured, which is alumina consisting, according to Thomson, of 100 parts of aluminum, and 8 of oxygen.

Amalgam. The alloy of mercury with any metal, if the mercury predominates so far as to render it soft, and of the consistence of butter, is called an amalgam. These amalgams are much employed in silvering and gilding, as the mercury is easily driven off by heat, and the fixed metal is left behind. The metal with which the backs of looking-glasses are coated, is an amalgam of tin and mercury.

Amalgam, *Electrical*. Various compounds are made under this name. They are differently prepared, but the best are made of tin and mercury, or zinc and mercury. Cavallo directs the amalgam of tin to be made by mixing two parts of mercury with one of tin-foil, adding a little powdered chalk, and mixing the whole until it becomes a mass like paste. For the amalgam of zinc, heat four or five parts of mercury higher than the boiling point of water, and have in readiness one part of melted zinc. Pour the heated mercury into a wooden box, and immediately after pour the melted zinc upon it. Close the box, and shake it for about half a minute. After the amalgam thus made is cold, mix it by trituration, with a small quantity of grease, such as tallow, mutton suet, &c., a very small quantity of finely powdered whitening,

and about a fourth part of the above amalgam of tin. This amalgam of zinc is the best.

Ammonia. The volatile alkali for which this is but another name, has already been noticed in our account of the alkalies; but we purpose on the present occasion going fully into its chemical properties, as well as its application to the useful arts.

Ammonia is obtained for actual use only from vegetable and animal substances, more especially the latter; in a few instances that we shall presently mention, it is also formed by the union of its constituent parts in the course of certain chemical experiments. The distillation of animal or vegetable matter has long been known to furnish an ammoniacal product, partly liquid, partly concrete, and capable of being purified by subsequent rectification, which has been termed salt or spirit of hartshorn, spirit of wine, &c., according to the substance employed.

In all these cases the volatile alkali is disengaged in a carbonated state, and is accordingly strongly effervescent with acids. This subject we shall refer to the articles *Carbonate of Ammonia*, and *Animal Matter*, and we shall here only describe the properties of ammonia in its pure and caustic state, and the facts which prove its chemical composition. All these facts are comparatively modern. Dr. Black first pointed out the difference between the caustic and mild alkalies, and the respective states of ammonia among the rest; and Dr. Priestley appears to have been the first who obtained this alkali in its purest form, that of a gas, and has termed it alkaline air.

Ammonia is thus prepared: Take any quantity of well-burnt lime, slack it with a little water, so as to reduce it to a powder, then mix it expeditiously with half its weight of dry muriate of ammonia in fine powder. On the instant of mixture, very pungent suffocating fumes of volatile alkali will be disengaged (which should be avoided, as they would excoriate the nostrils), and the mixture should be put into a retort of glass or earth, or into an iron or earthen tube, closed at one end, and closely fitted with a stopper, to which a bent glass tube is cemented. On the application of a very moderate heat, by a lamp or a pan of charcoal, the ammoniacal gas will be given off in great abundance for a considerable time, and to be examined chemically must be received in a jar filled with mercury and standing over the same fluid. In this operation the ammonia is disengaged from the muriatic acid, which combines with a portion of the lime, so that after all the alkali has been expelled, muriate of lime, with a great excess of lime, remains in the retort. This when duly heated is phosphoric. A much smaller quantity of lime is sufficient for the expulsion of the ammonia. Mr. Cornette found by direct experiment, that when equal parts of lime and muriate of ammonia were used, all the alkali was given out by heat, and in the residue which contained no undecomposed muriate of ammonia, nearly a fifth of the lime remained uncombined. On using three times the quantity of lime, no more ammonia was obtained than with only equal parts.

Many other substances will decompose muriate of ammonia and expel the alkali. The oxides of lead, minium, and litharge, assisted by heat, may be used with advantage, and the residue is muriate of lead. Water absorbs ammoniacal gas with great ease, but yields it again when heated to about 130°, and hence the liquid ammonia affords a very ready method of furnishing the gaseous alkali, nothing more being necessary than to put the liquor into a proof bottle with a curved tube, or any similar vessel, to heat it with the flame of a taper, and to collect the gas over mercury. No greater heat than necessary should be used, otherwise the steam of the water driven over along with the gas, will absorb it again rapidly on cooling.

Ammonia remains a permanent gas unaltered at any known temperature under a red heat. In this state it is intensely pungent and caustic, excoriating the nostrils when snuffed up unmixed, producing a most acrid sensation to the tongue and a dangerous constriction of the larynx. In a dilute form it is gratefully pungent and refreshing. Small animals immersed in it are instantly killed. The specific gravity of ammonia is not easily ascertained with perfect accuracy, owing to the extreme ease with which this gas combines with moisture in large proportions.

According to Mr. Kirwan's experiments, 100 cubic inches of this gas at 61° temperature and 30 inches barometrical pressure, weigh 18.16 grains. The same quantity of common air he estimates at 31 grains, and hence the alkaline air is lighter than the common air in the proportion of about 6.10. Therefore, as the specific gravity of common air (being 816 times lighter than water) is .0012255, the specific gravity of ammonia is .0007353. Other experiments nearly agree with this estimation of alkaline air.

This gas has been commonly represented as remarkably dilutable by heat, much more so than common air in similar circumstances. This has been actually observed by Priestley, Guyton, and other chemists, but it appears to apply only to this gas in its common state. The experiments of M. du Vernois prove that much of this expansion by heat is owing to the quantity of water that is vapourized along with the alkali, which quantity being variable, throws an equal irregularity on the results. He attempts however to give the following comparison as an approximation to the truth. 100 cubic inches of common air at 32°, and the same quantity of ammoniacal gas (procured from dry muriate of ammonia and lime) also at 32°, are respectively expanded at the different temperatures in the following ratio:

	Common air.	Common gas.
at 77°	107.89	127.91
122	125.70	184.87
167	165.74	358.78
212	193.68	680.09

But independently of the error arising from the admixture of aqueous vapour, it has been supposed that even in the heat of boiling water, a small portion of the alkaline gas is decomposed by the mercury over which it is confined, and which is generally slightly oxidated at the surface, and we shall presently see how readily the metallic oxides act upon the alkali.

Mr. Gay-Lussac, in his valuable experiments on the dilatation of gases, gives another cause of error in the experiments on alkaline air. In receiving the gas directly from the mixture of lime and muriate of ammonia, he did indeed find it much more dilatable by heat than common air; but on cooling the gas, he observed it to deposit a liquid with crystalline points of a salt, which he took to be either muriate or carbonate of ammonia, all of which again disappeared on raising the temperature. To exclude this impurity, he repeated the experiment with ammonia that had

previously remained in contact with potash, and now no longer gave this deposition on cooling. This gas was now found to expand exactly in the same ratio as common air by equal increments of heat from the freezing point to 203°.

A high heat decomposes the alkali, as will presently be seen.

Ammoniacal gas extinguishes flame. When a lighted taper is plunged into a jar full of this air, it immediately goes out, but just before extinction the flame is enlarged by a kind of halo of a pale yellow colour. The electric spark taken in it is red.

Ammonia combines with extreme rapidity with water, the easier as the water is colder. Heat is given out at the same time. Ice absorbs this gas with equal facility, and in so doing it appears to melt as fast as if a red-hot iron were applied to it. Sir Humphry Davy's experiments on this subject are useful, and bear the marks of every practicable degree of accuracy.

This chemist found that 50 grains of water absorbed 17 grains of gaseous ammonia (rather more than a third of its weight; and according to the calculation given above, nearly 463 times its bulk); and by this absorption the bulk of the liquid was much increased, or in other words its specific gravity was diminished. Therefore the levity of such a solution is in direct proportion to its strength of alkaline impregnation. By calculation from two extreme terms, Sir Humphry Davy gives the following table of specific gravity of liquid ammonia, corresponding with the respective quantities of alkali and water in the solution. As this preparation is in constant use, we shall give the table, which may be of service in ascertaining its strength, and regulating the price which it should bear. The temperature is assumed to be 52°, but the changes in specific gravity from 40° to 65° are not materially different.

Spec. gr.		Ammonia.		Water.
.9054	contain	25.37	and	74.63
.9166	——	22.07	——	77.93
.9255	——	19.54	——	80.46
.9326	——	17.52	——	82.48
.9385	——	15.88	——	84.12
.9435	——	14.53	——	85.47
.9476	——	13.46	——	86.54
.9513	——	12.40	——	87.60
.9545	——	11.56	——	88.44
.9573	——	10.82	——	89.18
.9597	——	10.17	——	89.83
.9619	——	9.60	——	90.40
.9684	——	9.50	——	90.5
.9639	——	9.09	——	90.91
.9713	——	9.17	——	92.83

Liquid ammonia (the aqua ammoniæ puræ of the Pharmacopœias) is actually prepared from the same materials in two ways; in one, the liquid itself is distilled; in the other, the gas is received in water, and there absorbed. The former is the oldest method, and is still practised very largely. It is the following: slack two pounds of well-burnt quick lime with one pint of water; when thus reduced to powder, mix it with sixteen ounces of muriated ammonia already in powder, put it into a retort, add five pints ot cold water, and lute on a receiver capable of being kept extremely cool, if possible surrounded with ice. Then distil off, with a moderate heat, twenty ounces of the liquid, which will be the liquid ammonia, or caustic volatile alkali. It is to be observed that the ammonia is so much more volatile than water, that the whole of it comes over with the first pint or pint and a quarter of water, so that no advantage whatever is gained by continuing the distillation any longer. The rest of the water serves to keep the residue sufficiently liquid to be readily taken out of the retort. Twice as much lime as necessary is employed; but this excess serves to keep down any carbonic acid that might otherwise rise. The specific gravity of the liquid thus prepared is about .936, and contains about 17 per cent. of ammonia. The process should be conducted slowly, and the receiver kept very cool, or else the water will again part with the alkali; and this latter, escaping in the form of gas, may burst the vessels if tight, or run to waste if open.

The other method, which is neater and probably better in every respect, is to receive the gas from the lime and sal ammoniac in a known quantity of water, which will absorb it till saturated. No more water, therefore, should be added to the materials than is just sufficient to slack the lime (about half its weight); and to make a strong solution as can conveniently be kept in a summer heat, as much water should be employed to absorb the ammonia as the weight of the muriated ammonia put into the distilling vessel. This last, instead of a wide neck, should terminate in a bent tube, plunged to the bottom of the water, and an apparatus similar to that of Woulfe's to prevent absortion. If the receiving bottle is surrounded with ice, the retort may be heated pretty rapidly.

As this liquid speedily absorbs carbonic acid from the air, it should be kept in well-closed bottles. The effect of heat upon it has been already mentioned to be the entire expulsion of the ammonia in the form of gas, and nothing but pure water is left. The effect of cold is singular. If cooled very low, ammonia loses much of the pungency of its smell (the alkali not being then so easily given off); at last, at the temperature of freezing mercury, (.40), it begins to crystallize in brilliant flexible needles; or if more hastily cooled to this intense degree, or even still lower, it becomes grey, semi-transparent like glue, or like silex in its gelatinous-precipitate form, and with scarcely any scent.

Many other liquids will absorb ammoniacal gas. Alcohol does it with great ease, and appears but little altered by it. We shall now relate some of the numerous experiments that incontestibly prove that ammonia is a compound substance, which are both analytical and synthetical, this alkali being decomposed in a variety of processes, and in a few, being formed by direct union of its constituent parts.

Dr. Priestley's experiments are among the first in the decomposition of this alkali. On passing the electric spark through this gas, he found it to be permanently enlarged after every shock, and when water was admitted, just so much remained unabsorbed as had been added by the explosions. The air was now strongly inflammable, detonating when mixed with common air, as violently as the inflammable air from metals. The colour of the electric spark was red in this air, as in hydrogen. The extent of dilatation, Dr. Priestley found to be about three times the original bulk of the ammoniacal gas, and when at its extreme degree, no portion of the electrified air was now absorbed by water. He afterwards found that mere heat would produce a similar effect, though less perfectly, for on pass-

ing alkaline air through a red-hot tube, part of it was changed to inflammable air, and part went through unaltered. Inflammable air, or hydrogen, is therefore thus proved to be one constituent of ammonia. The other is detected by the following beautiful and simple experiment. Having previously found that the oxides of lead were revived when heated in inflammable air, Dr. Priestley tried the same with ammoniacal gas, and found that massicot (an oxide of lead) was thereby reduced to reguline lead, with a certain diminution of the air, but not so complete as when hydrogen alone was employed; for the alkaline air, after it would reduce no more of the metal, left a large residue, which Dr. Priestley, to his surprise, found to be nitrogen or azotic gas. Red mercurial oxide was in like manner reduced in alkaline air; water was generated in a very sensible quantity, and the residue, as before, was azotic, mixed with some oxygen gas from the mercurial oxide. These experiments of the electrization of ammonia, and of the reduction of metallic oxides, have been confirmed by many other chemists.

The partial decomposition of volatile alkali by metallic oxides did not escape the acute observation of Scheele. This eminent chemist observed that liquid ammonia, when suffered to remain in contact with oxide of manganese and nitrous acid, was entirely decomposed, and furnished an elastic gas, whilst the oxide of manganese was so far reduced to the metallic state as to become soluble in the nitrous acid. The ammonia, therefore, furnished hydrogen to the oxygen, to seperate it in the form of water from this metal, and the other part of the ammonia, the nitrogen escaped in a gaseous form; thus convincing by its composition.

But the most accurate and convincing experiments on this alkali were undertaken by M. Berthollet, on the facts discovered by Priestley and Scheele. M. Berthollet first ascertained that on the distillation of nitrous ammonia more water was produced than belonged to the crystallization of the salt, and that the source of this water was the mutual decomposition of the acid and the alkali; the former supplying the oxygen, and the latter the hydrogen.

M. Berthollet also repeated the experiment of the reduction of metallic oxides on ammonia. Oxide of copper dissolved in this alkali, evaporated to dryness, and afterwards strongly heated, became completely reduced; water was formed, and nitrogen gas given out, together with some ammonia that had escaped decomposition. Hence M. Berthollet beautifully explained the detonation of fulminating gold, and even confirmed it by actual experiment in close vessels. This preparation is oxide of gold combined with ammonia; when heated it detonates vehemently, the gold is reduced, water is suddenly formed, and nitrogen gas given out.

Another singular phenomenon, also observed by M. Berthollet, is explained by the decomposition of ammonia. When oxymuriatic acid is mixed with liquid ammonia, a strong effervescence takes place, though the alkali contains no carbonic acid; a gas is given out, and the acid immediately loses its characteristic properties, becoming simple muriatic acid.

This is beautifully explained by the decomposition of ammonia, the hydrogen of the alkali uniting with the excess of oxygen in the acid into water, and the nitrogen of the alkali appearing uncombined in a gaseous form; for the effervescing gas when examined is found to be azotic. A crowd of interesting experiments, subsequent to these above mentioned, come in confirmation of this hypothesis of the decomposition of ammonia. M. Fourcroy, on passing the oxymuriatic acid gas into liquid ammonia, obtained a large quantity of azotic gas, which was collected in the pneumatic trough. On adding ammoniacal gas to oxymuriatic gas, a white flame was produced, and water was immediately seen trickling down the sides of the vessels.

The same chemist has also pursued the experiments with ammonia and metallic oxides. Liquid ammonia added to nitrate of mercury in solution, precipitates the metal black, and nearly metallic, and azotic gas is given out. The same takes place more strikingly with liquid ammonia, and red mercurial oxide in powder. A strong effervescence of azotic gas takes place, the oxide turns first white, then black, and on being moderately heated becomes mostly running mercury. The black oxide of manganese, moistened with ammonia in like manner, effervesces slightly even at a cold temperature, the metal is particularly reduced and becomes grey, and azotic gas is formed.

Nitrate of iron treated with ammonia, is equally reduced to the state of the least oxydation, and the precipitate is the black oxide of iron.

Many of the neutral ammoniacal salts when strongly heated, are partly sublimed and partly decomposed. The nitrate of ammonia has been already mentioned. Mr. Chenivix found that the sulphate of ammonia being distilled, gave out first the water of crystallization, then part of the salt sublimed unaltered, after which came over sulphureous acid and azotic gas, which continued to the end of the process.

The alkali of muriate of ammonia, though not easily destructible by mere heat, is entirely decomposed by the nitric acid. Mr. Woulfe, by distilling one pound of nitric acid from four ounces of muriate of ammonia, found the acid to act with great vehemence on the salt, and the whole contents of the retort were distilled over in a liquid form, in which no trace of undecomposed ammonia could be detected. The nitric acid was also in part decomposed, and much azotic gas, mixed with some oxygen, was given out in the process.

It often happens that in the decomposition of the alkali, the nitrogen, which is one of the constituents of ammonia, instead of being given out in the form of gas, enters into new combinations, particularly with oxygen when present in excess, and forms nitrous acid. The particulars of this singular conversion will be given under this article, but it may be mentioned here, that Dr. Milner produced this acid by passing ammonia through heated oxide of manganese; Fourcroy the same, by ammonia and sulphate of mercury; and Proust the same, by strongly heating a mixture of ammoniacal gas with an excess of oxygen. If a smaller quantity of oxygen be used, the product of the gases, after detonation in a high heat, is merely water and azotic gas.

We have now to mention some of the experiments in which ammonia is produced by a mixture of its constituent parts.

Animal putrefaction, and the disorganization of all animal and many vegetable substances by fire, are processes of this kind, that are perpetually going on; for in neither instance can ammonia be traced in the substance in any notable quantity, before putrefaction or combustion. But chemistry furnishes us with more direct experiments.

An ammoniacal smell has often been observed accidentally by several chemists, where it was not expected; and more particularly in experiments with nitrous gas or acids, and various metallic oxides. This was noticed by Dr. Priestley, in a solution of nitrated copper mixed with iron filings, which had long stood together. Mr. Hauffman, of Colmar, has shown the same production of alkali, on mixing nitrous gas with the precipitate from acetate of iron. In this case the nitrous gas is rapidly absorbed by the iron precipitate, and at that time such an interchange of principles takes place, that a small portion of nitrate of ammonia is formed in the mixture. On adding lime or caustic potash, the ammonia is expelled and becomes sensible to the smell. A like production of volatile alkali always takes place when the green sulphate of iron is saturated with nitrous gas. This is a curious fact, and depends on very complicated affinities. It will be sufficient to observe in this place, that the azote of the ammonia is provided for in the nitrous gas, and the hydrogen in the decomposed water of the solution. Dr. Austin's experiments on the formation of ammonia are highly interesting. Dr. A. found that no mixture of the two constituents, hydrogen and azote, when both in a gaseous form, could be brought to unite into ammonia, either by mixture in any proportion, or by any third addition. Even when the two gases were the identical parts of a given quantity of ammonia, decomposed by electricity, they could not again be re-united in their alkaline form. Dr. A. attributes this, probably with reason, to the great difference of specific gravity between the two gases, and hence he was led to attempt an union between the two, by putting the hydrogen in contact with azotic zas at the instant of its formation, before it had perfectly assumed the form of hydrogen gas, or as it is termed in its nascent state. This method succeeded. Iron filings, which are known to yield hydrogen soon after mixture with water, were moistened and inclosed in an atmosphere of azotic gas. In about twenty-four hours ammoniacal gas was detected, by the usual test of changing to green a piece of blue-stained paper which was suspended in the vessel. The green of nitrated copper on paper was also changed to blue by the same process in a few days. The same generation of ammonia took place in a few hours when nitrous gas was substituted for the azotic. On the other hand the same change occurred, though in a longer time, when common air was used instead of the azotic. Hence it would follow that a small portion of ammonia is always produced whenever iron rusts in the open air, or generally by every natural process which evolves hydrogen.

In the following simple experiment the volatile alkali is produced immediately in a very sensible quantity. Pour some moderately-strong nitrous acid upon an ounce or two of tin filings, sufficient to moisten them completely, and stir them together; the action will be immediate and vehement, and copious fumes of nitrous gas will arise; a very short time afterwards add some lime or dry caustic alkali, rub them together, and a very pungent smell of ammonia will be given out. In this experiment the ammonia which is formed from the decomposition both of nitrous acid and of water, first unites with another part of the acid, forming nitrate of ammonia, which might be procured as such from the mixture. Then, on adding the lime, this newly-formed salt is again decomposed, and the volatile alkali is expelled in its gaseous form. Zinc filings, moistened with nitrated copper, and mixed with lime, equally give out ammonia.

The method which has been pursued by M. Berthollet and succeeding chemists, of ascertaining the relative proportions of the two ingredients of ammonia (and indeed the only one practicable), has been first to resolve ammoniacal gas into its constituent parts, hydrogen and azotic gases (for which electricity offers a certain but tedious agent), and then to abstract the hydrogen by detonation with oxygen in Volta's eudiometer. The perfect resolution of the ammonia after electrization over mercury, is known by the enlargement ceasing, and by the electrized gas being now entirely unabsorbed when water is thrown up to it. In the subsequent detonation of the hydrogen (in which an excess of oxygen thould be employed) a great portion of the gas disappears; which loss, as it is accounted for by the production of water, must be estimated according to the known proportions in which hydrogen and oxygen constitute this fluid. The remaining gas (allowing for the excess of oxygen employed) is the azote, the other constituent of the ammonia. In this manner M. Berthollet estimates the composition of ammonia to be 121 by weight of azote, and 29 of hydrogen; supposing too that the comparative specific gravity of the former to the latter is as 11 to 1.

Sir Humphry Davy in his experiments decomposed his ammonia by transmission through a red-hot tube of green glass; after which he estimated the hydrogen and azote in the manner above mentioned, and the result coincided almost exactly with that of M. Berthollet.

An approximation to the same result is afforded by calculation from the known specific gravities of all the airs concerned in these experiments. According to Mr. Kirwan, 100 cubic inches of alkaline air weigh 18.16 grains, of azotic air weigh 30.535 grains, and of hydrogen gas weigh 2.613 grains. M. Berthollet reckons that 1.7 cubic inches of ammonia expands by electrization to 3.3, and consequently 100 cubic inches of the electrized air now weigh only 9.355 grains; and by subsequent calculation, Dr. Austin found that a mixture of this specific gravity is formed by 121 grains of azote, and 20 of hydrogen.

Ammonia combines with great ease with all the acids, forming neutral salts, which will be described under the respective acids. Its affinity for acids is weak compared to that of the other alkalies and many of the earths. It is a remarkable property of this alkali, that in many instances when added to earthy or metallic salts, where its affinity to the acid is on the whole greater than the basis already combined, it only partially decomposes them, uniting with the remainder of the salt into a triple compound, sometimes crystallizable, consisting of the acid, the earth, or metallic oxide, and ammonia. It is of importance to be aware of this in chemical analysis. The affinity of magnesia, for example, is so nearly the same as that of ammonia to acids, that ammoniaco-magnesian triple salts are constantly occurring when the three substances come together.

The frequent decomposition of ammonia upon metallic oxides, reducing them from the highest state of oxydation to the lowest, or even to the reguline state, has already been mentioned, when describing the

facts that prove the decomposition of this alkali. It also simply dissolves other metallic oxides, as copper, cobalt, zinc, nickel, tungsten, &c. Some of these compounds are crystallizable.

When ammoniacal gas is mixed with some of the gaseous acids, the carbonic or muriatic for example, a most beautiful phenomenon occurs: the two gases instantly on mixture form a dense white cloud, totally lose their gaseous form, and condense into minute flakes of the dry crystallized ammoniacal salt, so that, if pure, not an atom of gas is left in the vessel in which they are mixed. A rapid and complete absorption therefore is the consequence, and this is attended with a very sensible evolution of heat.

This circumstance affords a very delicate test of ammonia; for if any of the alkaline gas is given off from any substance (suppose an uncorked bottle of liquid ammonia), and a glass rod, straw, or any thing of the kind be only moistened with muriatic or nitrous acid, and held in the ammoniacal atmosphere, the alkali floating in the air will immediately be detected by the thick white cloud of nitrate, or muriate of ammonia, which will be seen to hover round the acid. This test is even more delicate than the smell. The caustic powers of the volatile alkali are much inferior to those of the two fixed. It does not readily corrode animal matter. With oil it unites readily to a certain degree, but not so firmly and perfectly as the fixed alkalies.

Sulphur may be made to combine with ammonia by distillation. Some interesting products are the result.

The constant tendency of ammonia to assume the gaseous state, in a very moderate heat, forms a considerable obstacle to its union with many bodies with which the fixed alkalies may be made to combine; of course there can be no such substance as an ammoniacal glass, it being impossible to combine it with the materials necessary to the formation of that substance.

Ammonia in its caustic state is used only in medicine and the laboratory. Ammoniacal gas is one of the best correctors to the dangerous suffocating properties of the vapour of oxymuriatic, and probably of other acids. In the event of such an accident, the speediest method will be to mix quick lime and muriated ammonia with a little water, and to place the vessel containing it on the floor, as near to the feet of the sufferer as can be borne with security, so as to allow him to inhale cautiously some of the ascending ammoniacal gas, which will be given off in great abundance.

Ammoniacal gas is detected, as we have before mentioned, by giving a dense white fume with muriatic acid vapour. It is known to be pure when it is totally and instantly absorbed by water. This test is in general sufficient, for the other rapidly absorbable gasses are the aeriform acids, which cannot remain in a gaseous state along with ammonia. If a small admixture of sulphureted hydrogen gas be suspected, the test of acetate of lead may be used, which will be blackened by water that has absorbed this gas, but not by liquid ammonia. The solution of ammonia in water is known to be perfectly deprived of carbonic acid when it gives no effervescence with acids, no cloudiness on mixture with strong alcohol, and particularly when it does not alter the transparency of a solution of pure lime (calcareous spar or Carrara marble) in the nitrous, muriatic, or acetic acids. This last, which is a most delicate test, should be made in a well-corked bottle; for though pure ammonia will not precipitate lime, carbonate of ammonia will do it very readily; and the alkali, if exposed to the air, will speedily absorb from it sufficient carbonic acid to render this test fallacious. If muriate of ammonia is accidentally mixed with liquid ammonia in the process of distillation, the presence of the muriatic acid is thus detected: saturate part of the liquor with pure distilled vinegar, and add to it a few drops of nitrated silver, a white precipitate of luna cornea will then indicate the muriatic acid, for nitrate of silver is not clouded by pure acetate of ammonia. We may add, that in the analysis of any substance supposed to contain an ammoniacal salt, this alkali is best expelled by adding lime to the substance to be analyzed, and distilling the whole in a close vessel. The whole of the ammonia then comes over with the very first products, and if condensed by a little water in a cool receiver, it is thus obtained in a concentrated state convenient for further examination.

The affinities of ammonia are the same as those of potash and soda in the moist way, but the tendency of the volatile alkali to gasification on the application of heat is so strong as to throw some uncertainty on its relative affinities, even at a moderately elevated temperature.

Ammoniacal Preparations, in *Pharmacy*. There are several pharmaceutical preparations, into which the volatile alkali, under one form or another, enters as a principal ingredient. Of these the only one in which the alkali is employed in its caustic state, is the aqua ammoniæ puræ (*Pharm. Lond.*), also called caustic spirit of ammonia, or spirit of ammonia with quick-lime (spiritus ammoniæ cum calce viva), the method of preparing which has already been described.

It may be observed, that though it is called a spirit it only consists of water impregnated with pure ammonia through the medium of distillation. The appellation, "with quick-lime," is added to distinguish it from the simple spirit of sal-ammoniac, which is prepared (from the distillation of muriate of ammonia in both cases, but) with chalk, and is therefore not caustic, but carbonated, and effervesces with acids.

The several preparations of the carbonate of ammonia employed in medicine, will be mentioned more particularly under that article and *Hartshorn*. The principal are the prepared ammonia, ammonia preparata (*Pharm. Lond.*), sal volatile, salt of hartshorn, which is the solid carbonate of ammonia in its pure state, prepared for the most part by sublimation of some of the neutral ammoniacal salts with chalk.

Aqua ammoniæ (*Pharm. Lond.*), or spirit of sal-ammoniac, is prepared by distilling muriate of ammonia, chalk, and water; and is in fact nothing but a solution of carbonate of ammonia in water, effected by the medium of distillation, and perhaps containing a small portion of the caustic ammonia, where the chalk is not perfectly mild. Sometimes this liquor is prepared with pearlash, or carbonate of potash instead of chalk. The effect will be the same upon the ammoniacal liquor, only when the pearlash is used, as it is always in a semi-caustic state, it will render the volatile alkali somewhat less carbonated.

Spiritus ammoniæ (*Pharm. Lond.*), spiritus salis ammoniaci dulcis sive vinosus. This differs from the preceding in being a real distilled spirit, as proof

spirit of wine is the menstruum employed for the alkali instead of water. The term spirit is therefore, in the present *London Pharmcopœia*, very properly confined to the ammoniacal preparations where spirit of wine is employed; and the term, water of ammonia, is adopted where this liquid is the solvent for the alkali.

The true spirit of ammonia is made the basis of several powerful compound preparations, in which either an aromatic oil and water or a fetid gum is united with the alkaline spirit, according to the intention which it is to answer. Of the former kind is the spiritus ammoniæ compositus, or volatile aromatic spirit, prepared by dissolving bergamotte essence and oil of cloves in the alkaline spirit (either with or without the help of distillation); of the latter is the spiritus ammoniæ fœtidus, in which a certain quantity of assafœtida is dissolved in the spirit. The ammoniacal spirit is likewise made the basis of some tinctures, instead of simple spirit of wine, where the operation of the volatile alkali properly combines with that of the gum or resin dissolved in the tincture.

Amplitude, in *Astronomy*, is an arch of the horizon, intercepted between the true east or west point, and the centre of the sun, or a star, at its rising or setting, so that the amplitude is of two kinds; ortive or eastern, and occiduous or western. These are also called northern or southern, as they fall in the northern and southern quarters of the horizon; and the complement of the amplitude, or the distance of the point of rising or setting, from the north or south point of the horizon is called the azimuth. To find the sun's or star's amplitude, either rising or setting, by the globe, see Globe.

To find the sun's amplitude trigonometrically, having the latitude and the sun's declination given. Say, as the cosine of the latitude is to the radius, so is the sine of the sun's or star's declination to the sine of the amplitude. Suppose, e. gr. the latitude to be that of London, viz. 51° 32′, and the declination 23° 28′; then cosine 51° 32′, or 9.7938317 : rad. or 10.0000000 :: sine of declination 23° 28′, or 9.6001181 : 10.0000000 + 9.6001181 — 9.7938317 = 9.8062864, or sine of the amplitude, or 39° 48′; and this is of the same name with the given declination, viz. north, when the declination is north, and south when the declination is south.

Amplitude, *Magnetical*, is an arch of the horizon, contained between the sun or star at its rising or setting, and the magnetical east or west point of the horizon, indicated by the magnetical compass, or the amplitude or azimuth compass; or it is the difference of the rising or setting of the sun, from the east or west points of the compass. To ascertain this, place the compass on a steady place, from which the horizon may be clearly seen, and looking through the sight-vanes of the compass, turn the instrument round, till the centre of the sun or other celestial object may be seen through the narrow slit which is in one of the sight-vanes, exactly in the thread which bisects the aperture in the other sight-vane; and when the centre of the celestial object, whether rising or setting, is just in the horizon, push the stop in the side of the box so as to stop the card, and then read the degree of the card which stands just against the fiducial line in the box; and this gives the amplitude required. In this operation allowance must be made for the height of the observer's eye above the level of the sea. The difference between the magnetical amplitude, thus observed, and the true amplitude, obtained by the last article, is the variation of the compass.

Analysis, in *Philosophy*; the mode of resolving a compound idea into its simple parts, in order to consider them more distinctly, and arrive at a more precise knowledge of the whole. It is opposed to *synthesis*, by which we combine and class our perceptions, and contrive expressions for our thoughts, so as to represent their several divisions, classes, and relations. *Analysis* is regressive, searching into principles; *synthesis* is progressive, carrying forward acknowledged truths to their application.

Analysis, in *Mathematics*, is in the widest sense the expression and developement of the functions of quantities by calculation. There are two ways of representing the relations between quantities, by construction, and by calculation. Pure geometry determines all magnitudes by construction, that is, by the mental drawing of lines, whose intersections give the proposed quantities; analysis, on the contrary, makes use of symbolical formulæ, called *equations*, to express relations. In this widest extent of the idea of analysis, algebra, assisted by literal arithmetic, appears as the first part of the system. Analysis, in a narrower sense, is distinguished from algebra, inasmuch as it considers quantities in a different point of view. While algebra speaks of the known and unknown, analysis treats of the unchanging or constant, and of the changing or variable. The algebraic equation, $x^2 + a\,x - b = 0$, for example, seeks an expression for the unknown x by means of the known a and b; but the analytical equation, $y^2 = ax$, expresses the law of the formation of the variable y, by means of the variable x, together with the constant a. In its application to geometry, analysis seeks by calculation the geometrical magnitudes for an assumed or undetermined unit. The analysis of the ancients was exhibited only in geometry, and made use only for geometrical assistance, in which it is distinguished from the analysis of the moderns, which, as before said, extends to all measurable objects, and expresses in equations the mutual dependence of magnitudes. But analysis and algebra resemble each other in this, that both reason in a language, into the expressions of which certain conditions are translated, and then, according to the rules of the language, are treated more fully in order to arrive at the result. Analysis, when considered in this light, appears to be the widest extent of the province of this language. Analysis, in the more limited sense, is divided into lower and higher, the bounds of which however run very much into one another. While we comprise in lower analysis, besides arithmetic and algebra, the doctrines of functions, of series, combinations, logarithms, and curves, we comprehend in the higher the differential and integral calculus, which are also included in the name *infinitesimal calculus*; the first of which the French consider as belonging, in a wider sense, to the *théorie des fonctions analytiques*.

Anatomy. This term, strictly speaking, implies but the cutting to pieces, or artificial separation of the different parts of any body. We purpose however in the present article, in the first instance, to give a brief history of the science in its general connection with the healing art, and then to describe in a systematic, yet concise way, the general mechanism of the human structure.

Anatomy, as a science, does not appear to have been of such general antiquity as its importance would lead us to suppose. Neither the Jews or Phoenicians paid much attention to it. We find by the writings of Plato, that that distinguished philosopher and his scholars had carefully considered the human body, both in its organization and functions; and though they had not arrived at the knowledge of the more minute and intricate parts, which required the successive labour and attention of many ages, they had formed very noble and comprehensive ideas of the subject in general. The anatomical descriptions of Xenophon and Plato have had the honour of being quoted by Longinus as specimens of sublime writing; and the extract from Plato is still more remarkable for its containing the rudiments of the circulation of the blood. "The heart," says Plato, "is the centre or knot of the blood-vessels; the spring or fountain of the blood, which is carried impetuously round; the blood is the *pabulum* or food of the flesh; and for the purpose of nourishment, the body is laid out into canals, like those which are drawn through gardens, that the blood may be conveyed, as from a fountain, to every part of the pervious system."

Hippocrates was nearly contemporary with the great philosophers of whom we have been speaking, and flourished about 400 years before the Christian era. He is said to have separated the professions of philosophy and medicine, and to have been the first who applied to the latter alone as the business of his life. He is likewise generally supposed to have been the earliest writer upon anatomy, as we are unacquainted with an express work of any previous author upon that subject, and as the first anatomical dissection which has been recorded, was made by his friend Democritus of Abdera. If, however, we read the works of Hippocrates with impartiality, and apply his accounts of the parts to what we now know of the human body, we must allow his descriptions to be imperfect, incorrect, sometimes extravagant, and often unintelligible, those of the bones alone excepted. He seems to have studied this portion of the frame with more success than any other, probably because, as he tells us, he had an opportunity of seeing a human skeleton.

After the death of Hippocrates, the study of anatomy was prosecuted with zeal at Athens by the most eminent philosophers of the period, among whom we find Aristotle and Theophrastus. But few of the writings of the former were made public during his lifetime; he affected to say that they would be unintelligible to those who had not heard them explained at his lectures; and, except the use which Theophrastus made of them, they were lost to the world for nearly two hundred years; and at last came out defective, and corrupted by men who, without proper qualifications, presumed to correct and supply what was lost. From the time of Theophrastus, the study of natural knowledge at Athens began to decline, and the reputation of the Lyceum and Academy was almost confined to the studies which are subservient to oratory and public speaking.

When Athens began to lose its celebrity as a medical school, that of Alexandria increased and flourished. The first Ptolemies, both from their love of literature, and a desire to give true and permanent dignity to their empire and to Alexander's favourite city, established a splendid school in the palace itself, with a museum and a library, which has been considered as the most famous in the world. Anatomy, with the other sciences, was publicly taught; and the two most distinguished professors were Erasistratus, the pupil and friend of Theophrastus, and Hierophilus. Their voluminous works are all lost; but they are repeatedly quoted by Galen. These professors were probably the first who were authorized to dissect human bodies; a peculiarity which marks strongly the philosophical magnanimity of the first Ptolemy, and fixes a great era in the history of anatomy. And it was no doubt from this particular advantage which the Alexandrian philosophers had above all others, that their school not only gained, but for many centuries preserved, its great reputation for medical science. Ammianus Marcellinus, who lived about 650 years after the schools were established, says "they were so famous in his time, that it was enough to secure credit to any physician, if he could say that he had studied at Alexandria."

The first Greek physician established in Rome was Archagathus, who flourished about 220 B. C., and was banished the city on account of the severity of his operations. About a century after Archagathus, and in the time of Pompey, we find Asclepiades, who had attained such high reputation as to be ranked in the same class with Hippocrates. He seemed to have some notion of the air in respiration, acting by its weight; and in accounting for digestion, he supposed the food to be no farther changed than by a comminution into extremely small parts, which being distibuted to the several portions of the body, assimilated itself to the nature of each. It is curious, that about this period, Cassius, a disciple of Asclepiades, accounted for the right side of the body becoming paralytic on injuring the left side of the brain, in the same manner as many modern writers have, viz. from the crossing of the nerves from the right to the left side of the brain.

From the time of Asclepiades to the second century, physicians seem to have been greatly encouraged in Rome, and in the writings of Celsus, Rufus, Pliny, Cœlius, Aurelianus, and Aræteus, we find several anatomical observations, which are however mostly very superficial and inaccurate. Towards the end of the second century lived the celebrated Claudius Galenus of Pergamus, whose name is so well known in the medical world. He applied himself particularly to the study of anatomy, and rendered greater services to the science than all who preceded him. He seems however to have been at a great loss for human subjects to operate upon; and therefore his descriptions of the various parts of the body are mostly taken from the inferior animals. His works contain the fullest history of anatomy, and the most complete system of the science to be met with any where before him, or for several centuries after.

About the end of the fourth century, Nimesius, Bishop of Emissa, wrote a treatise on the nature of man, in which it is said were contained two celebrated modern discoveries; the one the uses of the bile, boasted of by Sylvius de la Boe; and the other, the circulation of the blood. This last, however, is proved by Dr. Friend, to be falsely ascribed to this author.

The Roman empire now began to suffer from the inroads of various barbarous tribes, and learning declined; and when the empire was totally overwhelmed, every appearance of science was almost extinguished in Europe. The only remains were to

be found amongst the Aarbians in Spain and in Asia. The Saracens, who came into Spain, destroyed at first all the Greek books which the Vandals had spared; and though their government was a constant struggle with the Christian powers for many centuries, till they were driven out, they thus acquired a taste for learning which they conveyed to their countrymen in the east; several of their princes encouraged liberal studies; public schools were set up at Cordova, Toledo, and other towns, and translations of the Greeks into Arabic were universally in the hands of their teachers.

By this means was the learning of the Grecians transferred to the Arabians, who, however, though they had so good a foundation to build upon, were satisfied with commenting upon Galen, and seem to have practised no dissections on human bodies. In the tenth century, Constantine, a native of Bagdad, brought with him the Arabian doctrines on medicine to the Solernitarnian school in Sicily; and here anatomy began slowly to revive. In the fourteenth century, Mundinus dissected human bodies in Italy, and by degrees other nations acquired that useful art.

Anatomical knowledge, on its revival in Europe, was greatly promoted by the exertions of eminent painters, who were early and accurate dissectors, correctly delineating the muscles, after they had removed the integuments which covered them. Raphael, Titian, and Leonardo da Vinci were famous for their anatomical skill, which is indeed sufficiently evident in their paintings. A number of sketches, designed as studies by Leonardo da Vinci, are still extant in his Majesty's collection of drawings, and are spoken of by Dr. Hunter in the most encomiastic terms. Albert Durer, who is also ranked by Haller among the restorers of anatomy, published many plates representing the proportions and gestures of the human form and countenance.

When the Turks had subdued Greece, the inhabitants fled for safety to the western nations of Europe, bringing with them the Grecian authors on medicine, and translating them; and the invention of printing, which happened about the same time, greatly favoured their dispersion throughout Europe. An opportunity was now afforded of becoming acquainted with the writings of Galen and the ancients, and by these means, of arriving at the source of that knowledge which they had hitherto obtained only through the channel of the Arabian physicians. The superiority of the former was soon discovered, and the opinions of the Grecian writers were considered, even in anatomy as incontrovertible.

In the middle of the sixteenth century several eminent anatomists flourished, among whom were Sylvius and Vesalius, Fallopius and Eustachius. Sylvius taught anatomy in Paris in 1532. Vesalius was the first who recommended the injection of coloured fluids into the vessels of the body, in order to facilitate the labour of minutely tracing them. Whilst he was a student in college, he pursued anatomical inquiries with great ardour and assiduity, and published some of his discoveries before he was twenty-five years of age, and seven books on the anatomy of the human body before he was twenty-nine, A. D.1542. These books contain great discoveries, and in many circumstances correct the ancients. But although they have entitled their author to the gratitude of posterity, they procured to him scarcely any thing but animosity from his contemporaries. At that time the authority of Galen was held in high veneration; and when Vesalius exposed his errors, the hatred of all seemed turned against him. But knowledge was increased by these contentions; all parties were obliged to refer for the materials and support of controversy, to the book of nature, which they could not consult without receiving instruction. Even Vesalius was detected, in some instances, in the error with which he charged Galen—that of describing the anatomical structure of the human body from the dissection of brutes. In 1561, Fallopius, in Italy, published his *Observationes Anatomicæ;* he was an indefatigable anatomist, and made great discoveries. About the same time Eustachius made himself conspicuously eminent by promoting anatomical knowledge. He seemed calculated for subtle investigations; he drew many figures of the human body, and engraved his own plates, the accuracy of which cannot fail of exciting surprise in an anatomist of the present day. When the labours of these eminent men had, as it were, smoothed the path, anatomy was taught with a moderate degree of correctness and minuteness in the different schools of Europe. "Shortly after," as Haller has observed, "the different nations being engaged in war, the same attention was not paid to public institutions and dissections. Anatomists had therefore recourse to the examination of the bodies of brutes, from which they derived many important discoveries."

Early in the seventeenth century the circulation of the blood was discovered by Dr. Harvey, who was born at Folkestone in Kent, on the 2d of April, 1578.

Dr. Harvey studied at the University of Cambridge, and afterwards travelled through France and Germany to Padua in Italy, where he was honoured with the degree of Doctor of Medicine. On his return to England, he became a graduate in medicine at Cambridge, and afterwards settled in London; and in the year 1615 was made a Fellow of the London College of Physicians. In the following year he read a course of lectures, developing the circulation of the blood, and with such accuracy that no improvement in it has been made, although the discovery took place two hundred and fifteen years ago.

It is a surprising coincidence, but not more surprising than true, that when one discovery has been made another has quickly followed; and in this place it is strikingly exemplified by Asellius discovering the lacteals, which Pecquect traced to the thoracic duct, and thence to the left subclavian vein. About thirty-eight years after Harvey had discovered the circulation of the blood, Rudbeck and Bertholin discovered the tubes called lymphatics. This discovery was not made from the joint, but individual, efforts of those anatomists, each being unacquainted with the other's discovery until after it had been published, which occurred about the same time. The description which Bertholin gave of the use of this system of vessels was more generally approved than that given by Rudbeck, consequently his merits were duly appreciated. Although Bertholin's description was superior to that of his contemporary Rudbeck, still this explanation was very imperfect, and became the subject of Glisson's consideration, from whom it received considerable improvement. The discovery of the lymphatic system left little to be accomplished by anatomists of the seventeenth, eighteenth, and present centuries, further than confirm what had been previously discovered, and direct their attention to a further and correct knowledge of the functions

and use of the various parts of the human body. Amongst the vast nnmber who have thrown considerable light upon anatomy, and particularly physiology, the following names stand prominently conspicuous, viz. Albinus, Cooper, Highmore, Cheselden, Lewenhoeck, Malpighi, Willis, and Winslow, in the seventeenth century; and in the eighteenth, Haller, Morgagui, Scarpa, Soemmering, Monro, Hunter, Cruickshanks, and Bell. Those of the present are Abernethy, Blizard, C. Bell, Bichat, Cooper, Majendie, and Cuvier.

Of the discoveries of these distinguished anatomists and physiologists, full accounts will be given under their distinct departments of science.

The solids consists of fibres or small filaments, which differ in their degrees of hardness or elasticity. They are divided into *integumenta*, the integuments; *ossa*, the bones; *cartilagines*, cartilages; *ligamenta*, ligaments; *membranæ*, the membranes; *vassa*, the vessels; *musculi*, the muscles; *nervi*, the nerves; and *glandulæ*, the glands.

Integuments are the coverings of the whole body, comprehending the *epidermis*, cuticle or scarfskin, which is the outermost; *rete mucosum*, a net-work immediately under the epidermis; *cutis vera*, the real skin, which retains and carries off all the humours of the body; *corpus adiposum, seu membrana adiposa*, the fat, a cellular substance containing an unctuous juice. To the above may be added *capillus*, the hair, which consists of cellular filaments, and is denominated the beard, eye-lashes, &c, according to the place in which it grows (see HAIR); *unguis*, the nails, which are horny substances.

Bones are hard and brittle substances composed of *lamellæ*, or plates lying upon one another, and joined together by transverse fibres. They are covered with an exquisitely sensible vascular membrane, called the *periosteum*, which on the cranium, or skull, is called the *pericranium*. On the surface of the bones are both eminences and cavities. The eminences are called processes, which are of two sorts, namely, the *epiphyses* and the *apophyses*. The *epiphyses*, or *appendices*, are as it were, parts added to the bone; the *apophyses* are set upon or growing to a larger bone, so as to make one, as the natal apophysis.

Processes have different names, according to their figure. A process like a ball is called *caput*, the head; when flattened, *condyle*; the narrow part of the process *cervex*, the neck. A rough process is a tuberosity; and one terminating with a sharp point *corona*, which from its resemblance to other substances is termed mastoid, styloid, anchoroid, spinal, &c. Long ridges are called *spinæ*, the sides of which are *labria*, lips. Processes which form the brims, are *supercilia*.

The cavities and depressions of bones are of two sorts, namely, *glanæ*, which are narrow and shallow, and *botylæ*, which are deep and wide. These are subdivided into pits, or small roundish holes; *furrows* or long narrow channels; *nitches*, or *notches*, small branches in the bones; *sinuosities*, broad but superficial depressions; *fossæ*, large deep cavities; *sinuces*, still larger cavities, within the substance of the bone itself; *foramina*, holes through the body of the bone. The internal structure of the bones consists of cells filled with a fluid fat called marrow, that is contained in follicles.

The juncture of the bones with each other is called articulation, from the *articules*, or joint, at the ends of the bones. This is of two kinds, namely, articulation, properly so called, and *symphysis*, connexion. Articulation and *synarthrosis*, or conjoined articulation. Diarthrosis is subdivided into *enarthrosis*, or the ball and socket, when a large head is received into a deep cavity; *arthrodia*, when a round head is received into a small cavity; *gynglimus*, when a bone receives, and is received into another bone. *Synarthrosis* is the fixing of two bones together without motion, which is of two kinds, namely, by ingrailing, or, as the joiners call it, dovetailing, which is termed *sutura*, a sutura, and by a junction on a more extended surface, which was termed *harmonia symphysis*, or connection, is that species of articulation which takes place through the medium of another body, this is either *synchrondrosis*, a cartilaginous connection; *syneurosis*, a ligamentary connection; *syssarcosis*, a fleshy muscular connection. (See article BONE.)

Cartilages are smooth white substances, which are harder than all the other solid parts of the body, except the bones. They are covered with a membrane called the *perichondium*.

Ligaments are close compacted fibrous substances. The ligaments at the joint are called capsular, because they retain in *capsular*, or bags, the mucilaginous liquor called *synovia*, with which the joints are kept moist.

The *muscle* is a bundle of fleshy or tendinous fibres, consisting of the belly or body, which is the fleshy part; the head and the tail, which are the tendinous parts; these are otherwise called *aponeuroses*, or tendons. The head is fixed on the immoveable joint called the origin, and the tail on the part to be moved, called the insertion. The membranes in which the muscles are inclosed, are called *vaginæ*, or sheaths. As the motions of the human body are performed by means of the muscles, they derive their names mostly from their office, as the *abductor*, *elevator*, *flexor*, *extensor*, &c. (See MUSCLE.) When muscles act in opposite directions, they are called antagonists; but when several concur in the same motion, they are termed *congeneres*.

Membranes are expended substances of a pliable texture, and fitted to serve as coverings for other parts of the body, as the *skin*, *peritoneum*, *plura*, *dura mater*, &c.

The *vessels* are ducts or canals, composed of membranes, the strata of which are called *tunicæ*, or coats. They may be divided generally into blood-vessels and absorbents. Blood-vessels, so called because they serve to circulate the blood through the body, are sither *arteriæ*, arteries, or *venæ*, veins; the former of which convey the blood from the heart, and the latter return it to the heart. (See ARTERY and VEIN.) The arteries have a beating motion, called the pulse, which the veins have not. This pulsation arises from what is termed the *systole* and *diastole*, i. e. the dilatation and contraction of the heart.

Absorbents, so called from their absorbing any fluid, and carrying it to the blood, are the *vasa lactea*, the lacteals; *vasa lymphatica*, the lymphatics; together with their common trunk, the lacteal sac and duct. The lacteals absorb the chyle, and the lymphatics the lymph. The lacteal sac, or *receptaculum chyle*, serves, as the name denotes, to retain the chyle; and sends it by the thoracic duct through the whole body. The lymphatics, with the lacteals of the intestines, form what is called the absorbent system. Most vessels are parted off into branches, which are again split

into smaller branches or ramifications, the last or smallest extremities of which are termed *capillary*.

Nerves are long white medullary chords, springing from the *cerebrum* or brain and spinal marrow, whence they are generally distinguished into the *cerebral* and *spinal nerves*. The cerebral are subdivided into the *olfactory, optic, auditory*, &c. nerves, according to their use. (See NERVE.) They go on in *bundles* or *pairs*, and are afterwards distributed into *branches, ramifications*, and *filaments*, over every part that is endowed with sensibility. In several places the nerves communicate with each other, which communication is called a *plexus*; in other places they unite into knots called *ganglions*.

Glands are secretory vessels, composed of all the different sorts of vessels inclosed in a membrane, and serving to secrete some fluid. As to their fabric, they are *conglobate* or *simple, conglomerate* or *compound*. As to their contents, *mucous, sebaceous, lymphatic, salival, lachrymal*, &c.

The *fluids* come next in order. Under this head we may place those humours or juices which serve either to sustain life or preserve the frame in a healthy state. The principal of those are *sanguis*, the blood; *chylus*, the chyle; *lympha*, the lymph; and *bilis*, the bile.

Blood is a red homogeneous fluid, of a saltish taste, a somewhat urinous smell, and glutinous consistence, which circulates in the heart, arteries, and veins.

Chyle, a milk-like liquor, secreted in the lacteal vessels, by digestion, from the chyme or indigested mass of food that passes from the stomach into the duodenum. The chyle is that fluid substance from which the blood is formed.

Lymph, a liquid contained in the lymphatic vessels has a fatuous smell, no taste, and a crystalline colour; its use is to return the superfluous nutritious jelly from every part, and to mix it with the chyle in the thoracic duct, for the purpose of furnishing nutriment to the animal.

Bile, a bitter fluid secreted in the glandular substance of the liver. In a healthy state it is a yellow-green colour, and of the consistency of thin oil. Its principal use is to seperate the chyle from the chyme, with which it mixes in the duodenum.

To the above might be added *pituita*, phlegm; *saliva*, spittle; *mucus*; *lachrymæ*, tears; *sudor*, perspirations; all excretions from the blood, and in a healthy state, passing off from the body at particular periods; of these more may be found under their respective heads.

Of these component parts in different proportions are formed the three principal divisions of the body before mentioned, namely, the head, the trunk, and the extremities.

The *head* consists of *caput*, the head properly so called, and *cervix*, the neck. The parts of the head are external or internal.

External parts of the head.—The external parts of the head are, the hairy scalp and the face. The hairy scalp is composed of the common integuments; its uppermost part is called the *vertex seu fontinella*, the crown; the fourth part, the *sinciput;* the hind part, *occiput*, or back of the head; and the lateral parts, *tempora*, the temples. The face comprehends *frons*, the forehead; *oculus*, the eye; *auris*, the ear; *nasus*, the nose; and *os*, the mouth.

The *eye* is composed, externally, of *supercilia*, the eye-brows; *cilia*, the eye-lashes; *palpebræ*, the eyelids, the angles of which are called *canthe*, the margin *tarsus; glandulæ lachrymales*, the lachrymal glands; *puncta, lachrymalia; canales lachrymalis*, lachrymal ducts; *saccus lachrymalis*, the lachrymal sac; *ductus nasalis*, the nasal duct; *membrana conjunctiva seu albuginea*, the white.

The *internal* parts of the eye compose what is called the ball or globe. These are *tunicæ*, the coats; *cameræ*, the chambers; and *humores*, the humours; besides the muscles, fat, nerves, and glands. The principal coats of the eye are *tunica sclerotica*, or the *cornea*, which is the external and thickest coat; *tunica choroidea*, or the choroides, which is the middle. The perforated septum of the choroides has the name of *uvea;* the anterior lamina of the septum is termed the *iris;* the radiated plicæ of the posterior lamina *processus ciliares;* and the hole near the centre of the septum *pupilla*, the pupil, which is capable of contraction or dilation. The third and innermost of the coats is the *retina*.—*Camaræ*, the chambers of the eye, are the *camera, anterior*, and *posterior*, situated between the *cornea lucida*, or the anterior portion of the sclerotica and the uvea.—*Humores*, the humours of the eye, are three, namely, the *aqueous humour*, which is contained in the two chambers; crystalline lens or humour; and the *vitreous humour:* these two are enclosed in capsular tunicæ, called *crystallina* and *vitrea*. All these soft parts are enclosed in a funnel-shaped cavity, called an orbit, which is formed by seven bones, namely, the *os frontis, os sphenoidale, os othmoides, os maxillare, os malæ, os unguis*, and *os palati*. (See EYE.)

The *ear* is divided into the external and internal.

Auricula, the *external ear*, consists of a large cartilage that is divided into two portions, namely, the *pinna*, which is large and solid; and the *lobas* or lobe, which is soft and small, and forms the lower part. The external ear contains, besides several eminences, namely, the *helix, anthelex, tragus*, and *antitragus*; and also some depressions, as the *fossa auricularis*, or *scapha*, the *concha*, and the *meatus*.

The *internal ear* consists of *meatus auditorius internus*, the internal auditory passage; *membrana tympani*, the membrane which separates the external from the internal parts of the ear; and the labyrinth, which consists of three portions, namely, *cochlea*, the anterior; *vestibulum*, the middle; and the semicircular canals. (See EAR.)

The *nose* consists, *externally* of the root; the arch; back or spine, called the *spina nasi;* the sides of the arch; the tip of the nose; the *alæ* or *pinnæ*, which are the sides of the nostrils; the *nares*, or external nostrils.

The *internal parts of the nose* are, the internal nares, which consists of the *septum narium;* the *subseptum*, or pillar of fat under the *septum narium;* the convolutions; the *conchæ superiores;* the *sinus maxillares*, and *sinus sphenoidales;* the *ductus lachrymalis;* the *ductus patatius*, and the *membrana pituitaria*, which lines the whole cavity of the nostrils. (See NOSE.)

The *mouth* consists *externally*, of *labia*, the lips, which are upper and lower, and composed of a border or edge, and of commissures or angles; *fossula*, the depression which runs from the *septum narium* to the edge of the upper lip; *cheeks*, the upper prominent part of which is called the *mala; chin*, the anterior protuberance by which the lower part of the face is terminated.

The *internal parts of the mouth* are *palatum*, the palate, or roof of the mouth; *septum palati*, or *velum*

palati, the soft part of the palate, which forms two arches; *ærula*, the conical fleshy substance at the root of the tongue; *amygdalæ* or *tonsillæ*, the tonsils, two glandular substances, one on each side the basis of the tongue; *gingivæ*, the gums which contain the teeth; *maxillæ*, the *jaws*, which are composed of bones, and are either upper or lower; the *fræna*, of the lips; *lingua*, the tongue which consists of an apex, a root or basis, and a frænum. (See MOUTH.)

The internal parts of the head must next be examined: they are contained within an oval cavity, called the *cranium* or *skull*, which is formed of eight bones. (See BONES.) The contents of the skull are comprehended under the general name of *cerebrum*, the brain, which is immediately surrounded by two membranes, which are called *matres*, i. e. the *pia mater*, and the *dura mater*, between which lies a third membrane, called the *tunicai arachnoidea*. The duplicatures or circumvotions of these membranes are called *septa*, the upper of which has the name of the *falx*. The cerebrum consists of three portions, viz. the *cerebrum*, or brain, properly so called; the *cerebellum*, or little brain; and the *medulla oblongata;* to which is added sometimes a fourth, namely, the *medulla spinalis*, which fills the great canal of the *spina dorsi*.

The *cerebrum* is divided into two lateral portions called *hemispheres*, the extremities of which are termed *lobes*. Its substance is of two kinds, namely the outer, that is cortical, and is called the *cortex*; and the inner, which is called the *substantia medullaris*, or *substantia alba*.

The cavities of the brain, called *ventricles*, are four in number, and separated by a membrane called the *septum lucidum*. In each of these is the *choroid plexus*, formed of blood vessels. There is also another small cavity or *fossula*, called the *infundibulum*, the superior opening of which is called the *foramen commune anterius*. The principal prominences are the *corpus callosum*, the lower side of which forms a sort of vault called the *fornix;* the *corpora striata*, two striated prominences; *thalami nervorum opticorum; corpora quadragemina*, four medullary projections originally called *nates* and *testes;* the *pineal gland*, a cerebune tubercle on the nates, and the *crura cerebri*, two medullary columns proceeding from the basis of the brain to the medulla oblongata. To these may be added the *glandula pituitaria*, a small spongy body in the selta sphenoidalis.

On the *cerebellum* are observed four eminences, called *appendices vermiformes;* a fourth verticle; a valve, called the *valvula magna cerebri;* lamina, or ramifications, called *arbor vitæ*, the trunks of which are termed *pedunculi cerebelli*.

The *medulla oblongata* is a medullary continuation of the cerebrum and cerebellum, having anterior branches called *brachia*, and posterior, called *crura medullæ*. Its transverse is called *processus annularis*. The extremity of the medulla is called the *cauda;* its tubercles, *corpora olivaria et pyramidalia;* to which may be added the *medullary papillæ*, that are productions of the *infundibulum*.

The lower parts of the *medulla spinalis* is called *caudina equina;* and, in other particulars, it resembles the parts before described. From the cerebrum, and the other parts of the brain, arise the nerves which are dispersed through the body, (See NERVES.)

The *neck* may be added either to the head or the thorax, or to both. The fore part is called the throat, and the hind part the nape. The parts of the throat are the *fauces*, a cavity behind the tongue; *larynx*, which consists of five cartilages, a part of the *trachea; pharynx*, a muscular bag which receives the masticated food; *æsophagus*, or *gula;* the throat, a membraneous and muscular tube.

The salival glands, which are three pair, namely the *glandulæ parotides*, *maxillares*, and *sublinguales*, so called from their situation. (See NECK.)

The *trunk* consists of *spina*, the spine; *thorax*, the chest; and *abdomen*, the belly.

The *spine* is a bony column, consisting of a chain of *bones*, called *vertebra*, which are divided into true or false. (See VERTEBRÆ, BONES.)

The fore part of the thorax is the breast, the hind part the back; the lateral part the sides. These are severally formed by *sternum*, the breast-bone; *vertebræ dorsi*, the dorsal vertebræ; and *costæ*, the ribs. (See BONES, &c.) The thorax has externally the *mammæ*, or breasts, in the middle of which is the *papilla*, or nipple, surrounded by a disc called the *areola;* within are the *tubuli lactiferi*, or lactiferous ducts. The cavity of the thorax contains the *pleura*, a membrane with which it is lined; *mediastinum*, a membraneous septum; *pulmones*, the lungs; *cor*, the heart, and *pericardium*, the heart purse, a membraneous bag within which it is inclosed. The largest part of the heart is called the base, the narrower extremity the apex. It is divided by a membrane called the *septum medium*, or *septum cordis*, into two cavities, called *ventriculi*, ventricles, having several eminences or inequalities, called *fossulæ*, *thymus gland*, *ductus thoracicus*, and the *ductus lacteus*. (See THORAX.)

The *abdomen* is divided into four regions, three of which are anterior, and one posterior.—The *anterior regions* are the *epigastrii*, or upper region, which is divided into the *epigastrium*, or middle, and the *hypochondria*, or lateral parts; the *umbilical*, or middle region, consisting of the *regio umbilicalis*, or navel, in the middle, and the *ilia* or flanks, on the sides; the *hypogastrii*, or lower region, which is divided into the *pubis*, or middle part, and the *inguina*, or groins, on each side. The posterior region is the *regio lumbaris*, or loins.

The cavity of the abdomen is separated from that of the thorax by the muscular diaphragm, called the midruff. Its *viscera*, or contents, are inclosed in a membrane called the *peritonæum*, and are as follow, namely, the *ventriculus*, the stomach, which has two orifices, namely, the *cardia*, which is the upper, and the *pylorus*, which is the lower. It is composed of three coats, namely, the outermost, which is *membraneous;* the middle, which is *muscular;* and the inner, which is *nervous*, and covered with vessels. To these has been added a fourth, called *villous*. The stomach performs the office of *digestion*, which is now generally supposed to be effected by the *saccus gastricus*, or gastric juice, which flows from the *tunica nervosa*, aided by the continual contraction and relaxation of the muscular tunic, which is called the *peristaltic motion*. The *intestines* are a long pipe or canal, which by its convolutions forms six portions, three small and three large, namely, the *duodenum*, *jejunum*, *ileum*, *cæcum*, *colon*, and *rectum*. The small intestines have valves or folds, called *valvulæ conniventes;* the large intestines have fatty appendages, called *appendiculæ epiploicæ*. The membranes belonging to the intestines

Fig. 1.

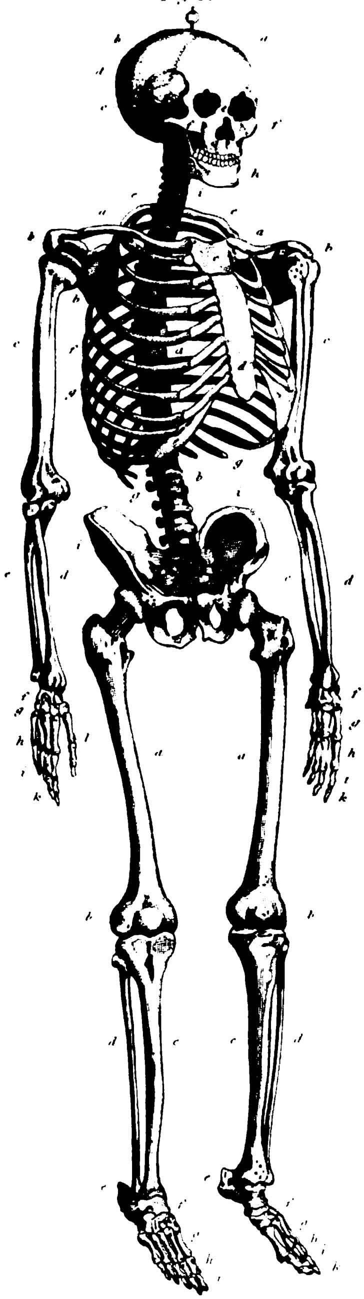
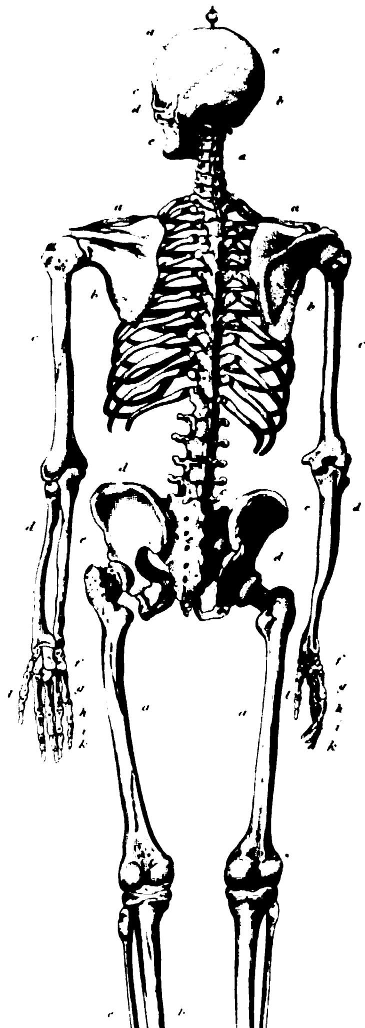


Fig. 2.



London. Published by William Orr: Pater... Row, Nov. 29. 1832

are the *mesentery*, *mesocolon*, and the *omentum*, or *epiploon*, by which they are kept in their places and preserved from injuries, whilst by their peristaltic motion they expel the fæces collected in them. *Hepar*, the liver, is divided into two lobes, and is suspended in the body by means of ligaments, which connect it with the diaphragm, &c. It is composed of small vessels, or the ramifications of vessels, called *folliculi*, or *pori biliarii*, because in them is secreted the humour called the bile. The ducts of the liver are the *ductus hepaticus*; the *ductus cysticus*; and the *ductus echlodochus*, which is composed of the two former. On the hollow side of the liver lies the *vesicular fellis*, or the gall bladder.—*Pancreas*, a glandular *viscus*, consists of innumerable small glands that form one duct, called *ductus pancreaticus*, the pancreatic duct; its office is to secrete a juice distinguished by the name of the *succus pancreaticus*, the pancreatic juice.—*Lien* the spleen, is connected with the stomach by its blood-vessels called *vasa brevia*.—*Renes*, the kidneys, are composed of three substances, namely, the external, which is cortical, the middle, which is tubular; and the inner substance, which is medullary. They have also a peculiar membrane called the *membrana propria*, and an excretory duct called the *ureter*, the origin of which, expanded into the form of a funnel, is called the *pelvis*.—*Urinaria vesica*, the urinary bladder, a fleshy membraneous pouch, is divided into the body, the fundus, or upper part, and the neck which is the lower part, that is, contracted by the sphineter muscle.

The lower part of the abdomen is, in the skeleton, called the pelvis, which is formed by the *ossa ilia* and *ischia*, the *os sacrum*, the *os coccygis*, and the *ossa pubis*, and is terminated anteriorly by the *pudenda*, and posteriorly by the *clunes*, or buttocks. (See Bones.) The space between the *anus* and *pudenda* is called the *perinæum*.

The *pudenda*, or organs of generation, are distinguished into the male and female. The male organs are the *testes*, *vesiculæ*, *seminales*, *prostatæ*, and *penis*. —The *testes* are composed of many minute vessels, convoluted into different heaps, by means of which is formed a body called the *epididymis*. They are enclosed in three integuments or coats, namely, the *scrotum*, common to both, the *tunica vaginales*, and the *tunica albuginea*; besides a muscular lining of the *scrotum*, called the *dartos*, by which it is corrugated. The principal vessels are the *vasa præparantia*, commonly called the spermatic chord, and the *vasa deferentia*. The most important muscle is the *cremaster*. *Vesiculæ seminalis* are two in number, on each side of the bladder, which serves as recepticles for the seed. —*Prostatæ*, or *corpus glandulosum*, a conglomerate gland, situated at the neck of the bladder.—The *penis* is composed of two spongy substances, called *corpora cavernosa*, and covered with a particular integument, called the præputium. The extremity of the penis is the glans, or *balanus*, and the ligament by which it is tied to the glans is the *frænum*. The canal or urinary passage of the penis is the *urethra*, in which is a longitudinal orifice, called the *meatus urinarius*.

The female organs of generation are external or internal. The external are the *vulva*, *mons veneris*, *labia nymphæ*, and *clytoris*, the branches of which are called the *crura*.—The internal parts are called the *vagina*, or neck of the womb, the *hymen*, and the *carunculæ myrtiformes*, formed from the hymen and the *uterus* or womb.

The *uterus* is divided into three parts, namely, the *fundus* or upper part; the body, and the *cervix* or lower part, the entrance into which is called the *os uteri*. It is tied by two sorts of ligaments, called *ligamenta lata*, and *ligamenta rotunda*, i.e. two broad, and two round. To one end of the *ligamenta lata* are tied the *ovaria* or *testes* in females; along the other end run the *tubæ fallopianæ*. The vessels of the *uterus* are subject to a periodical discharge, which is called *menstruation*, and that which is discharged, the *menses*. The formation of the parts of an animal in the womb constitutes a *gravid uterus*. The commencement of this process is called *conception* or *impregnation*; and that which follows is *gestation* till the time of delivery, when the young is brought forth. The first rudiments of the animal are called the embryo, which, with the *umbilical chord* and *membranes* constitute the *ovum*. When the parts of the embryo are to be distinguished from one another, it is termed the fœtus. The membranes of the *ovum* and fœtus are the *amnios*, which is true or false, and the *chorion*. These membranes contain a fluid, called the *liquor amnii*, in which the embryo floats; and from the flacculent vessels of the amnion is formed the vascular substance called the *placenta*. The placenta and membranes which come away after the birth of the child are known by the name of *secundines*, or after-birth.

The *extremities* are superior and inferior. The superior extremities consist of *summitas humeri*, the shoulder; *brachium*, the arm; and *manus*, the hand. —The shoulder is composed of *clavicula*, the collar bone; *scapula*, the shoulder blade; and *axilla*, the armpit.—The arm is composed of the *os humeri*, *ulna*, and *radius*, the two last of which make what is called the fore-arm, in which anteriorly is the bend of the arm, and posteriorly, *angulus cubiti*, the elbow. The hand consists of the *carpus*, or the wrist; *metacarpus* and *digiti manus*, or fingers; *dorsum manus*, the back of the hand; and *vola* the palm.

The inferior extremities consist of *coxa* or *regio ischiadica*, the hip; *femar*, the thigh; *tibia*, the leg; and *pes*, the foot.—The thigh is composed of the *os femoris*, the thigh bone.—The leg is composed of the *genu*, the knee; *tibia*, *fibula*, *patella*, the knee-pan; *poples*, the ham; *cavum poplitis*, the hollow of the thigh; *sura*, the calf; and *malleolus*, the ancle.—The foot consists of *tarsus*, the instep; *mitatarsus*, or *dorsum*, the back; *digiti pedis*, the toes; and *planta*, the sole.

Having thus given a general outline of the various parts of the human structure, we may now proceed to a more detailed view of the osseous frame-work from which it derives its form and stability.

Plate 1, Anatomy, *fig.* 1, represents a front view of the male skeleton.

Head and neck.—*a*, the frontal bone; *b*, the parietal bone; *c*, the temporal bone; *d*, a portion of the sphenoid bone; *e*, the nasal bone; *f*, the malar, or cheek bones; *g*, the superior maxillary, or upper jaw bone; *h*, the lower jaw; *i*, the bones of the neck.

Trunk.—*a*, the twelve bones of the back; *b*, the five bones of the loins; *c*, *d*, the breast bone composed of two pieces; *e*, *f*, the seven true ribs; *g*, *g*, the five false ribs; *h*, the rump bone, or sacrum; *i*, the hip bones.

Upper extremity.—*a*, the collar bone; *b*, the shoulder blade; *c*, the upper arm bone; *d*, the radius; *e*, the ulna; *f*, the carpus, or wrist; *g*, the bones of the

hand; *h*, the first row of finger bones; *i*, the second row of finger bones; *k*, the third row of finger bones; *l*, the bones of the thumb.

Lower extremity.—*a*, the thigh bone; *b*, the knee-pan; *c*, the tibia, or large bone of the leg; *d*, the fibula, or small bone of the leg; *e*, the heel bone; *f*, the bones of the instep; *g*, the bones of the foot; *h*, the first row of toe bones; *i*, the second row of toe bones; *k*, the third row of toe bones.

Fig. 2, represents a back view of the male skeleton.

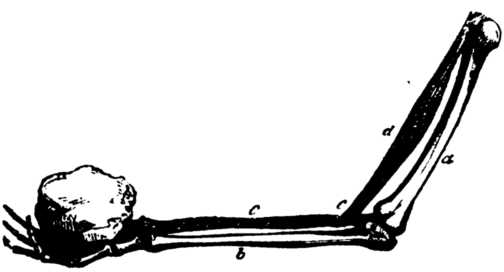
The head.—*a*, the parietal bone; *b*, the occipital bone; *c*, the temporal bone; *d*, the cheek bone; *e*, the lower jaw bone.

Neck and trunk.—*a*, the bones of the neck; *b*, the bones of the back; *c*, the bones of the loins; *d*, the hip bone; *e*, the sacrum.

Upper extremity.—*a*, the collar bone; *b*, the blade bone; *c*, the upper bone of the arm; *d*, the radius; *e*, the ulna; *f*, the bones of the wrist; *g*, the bones of the hand; *h*, the first row of finger bones; *i*, the second row of finger bones; *k*, the third row of finger bones; *l*, the bones of the thumb.

Lower extremity.—*a*, the thigh bone; *b*, the large bone of the leg; *c*, the small bone of the leg; *d*, the heel bone; *e*, the bones of the instep; *f*, the bones of the toes.

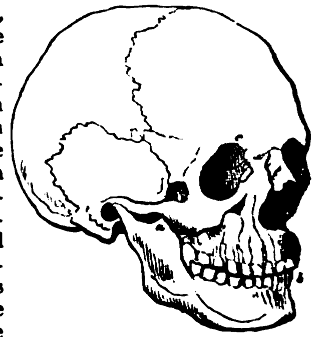
From this view of the human skeleton as a whole, we may proceed to an examination of the mechanical principles brought into operation in the various motions of the bones.



Both the lever and pulley perform prominent parts in animal mechanics. The arm furnishes us with a beautiful exemplification of the first of these simple mechanical instruments. In the above engraving our readers have a representation of the os humeri, *a*, nodius and ulna, *b*, *c*, with the connecting bones of the hand. Now, at first view, this arrangement appears but little fitted to answer any useful purpose, as the muscle or flexible cord *d*, which acts by its contraction from *e*, to elevate the weight in the hand, is placed nearer to the axis than the mass to be raised, and as such, strictly speaking, power is lost. But a closer examination shews that this mechanical disadvantage is more than compensated by the greater neatness and compactness of the limb. It lays nearer to the bone, and in addition to that circumstance there is less of contractible power required to move the extremity of the limb through a given space than if it acted directly at the point of the hand. The biceps and brachiæus exert a force equal to about twenty times that of the body raised.

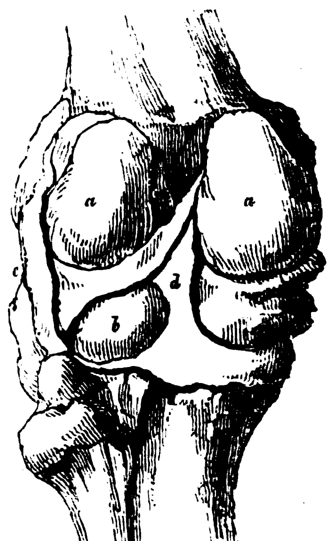
This force must not be confounded with the passive resistance of the bones, which frequently amounts to many hundred pounds, which a girdle passing round the lower extremities will readily support. In this way a man has been known to raise four butts of beer, and perform feats of strength which it would otherwise be difficult to understand.

Another, and very beautiful illustration, will be found in the head.



In the lower jaw, as shewn at *a b*, the the process goes on at a point much further removed from the centre of motion than the point where it is connected with the condyloid processes. On this account it is essential that a force much beyond that which is necessary for the mere crushing of the food should be exerted. In man it frequently amounts to three or four hundred pounds, and in the tiger, and some other of the inferior animals, to more than fifteen hundred pounds of effectual force,

While speaking of this portion of the human structure, we must not omit to notice two other mechanical powers, which are exhibited in the same figure. The teeth form very perfect illustrations of the use of the wedge, and a small perforation at *e* serves as a pulley to move the eye in its orbit.

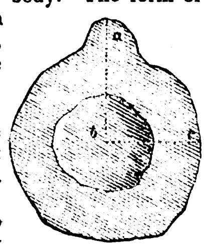


The way in which the axes or natural joints are lashed together, is represented in the accompanying engraving of the *tibia*; *a a* the apophyses are seen at the lower end of the os femoris covered with cartilage. The upper end of the *tibia* marked *b* and *d*, forms a ligament which moves a species of pulley or cartilage in the form of a half moon. A cross binding ligament which keeps the whole compact together is seen at *c*. Ligaments of a similar character are also represented at *e*. Now a more perfect axis or universal joint could hardly be conceived than the one thus described, and the ingenious mechanic cannot do better than go to nature for a guide in the general arrangement of the mechanical powers. A provision is also made for diminishing friction in the necessary motion of the ball and socket. A fluid constantly secreted serves precisely the same purpose as the reservoir arrangement in some of the new four-wheeled vehicles.

Another illustration of the wedge, as it occurs in conjunction with the theory of the arch, will not be out of place.

In the accompanying sketch the foot is seen supporting the lower end of the tibia, *a*. The os calcis, *b*, forms one point of support, whilst the toes being depressed by the muscular force form the other abutment. The series of bones from *a* to *c* form a system of wedges; and in addition to their great strength, act by their elasticity to break the momentum which the body of necessity acquires even in the falling or leaping from the smallest height.

Having thus illustrated some of the mechanical powers which are brought into operation in the human frame, we must briefly advert to the structure of the frame-work, or bones themselves. It was formerly believed that the bones consisted of fibres and lamella, but this view is now considered by the best anatomists as erroneous, and the view of Professor Scarpa of Pavia has been substituted. Considering it absurd to admit in one and the same bone two different structures, he has demonstrated by direct experiment, that the cellular, reticular, and vascular parenchyma constitute but the basis from which the other materials under apparently new forms are secreted, and that their intimate structure is in reality the same with that of the muscles, nerves, and several other parts of the body. The form of the bone best fitted for strength where elasticity is not required, is shown in the section. The marrow *b*, occupies the centre, and the bone formed in a circular layer, *a c*, has about three times the strength which it would possess if it assumed a solid form. The increased thickness exhibited at *a b*, serves to give the required strength in any peculiar direction. In closing this part of our subject we beg to direct the reader's attention to the articles *Muscles, Nerves, Brain*, &c.



ANCHOR. There are various species of metallic and wooden hooks, which under the general name of anchors are used for mooring of vessels. In the infancy of navigation, they appeared to have consisted of irregular masses of stone and bronze, which acted rather by the weight of the materials than the tenacity of the bed of the sea.

The anchors now generally made are so contrived as to support a great strain before they can be loosened or dislodged from their earth-bound bed. The parts of which an anchor is composed are the ring into which the cable is fastened, the beam or shank, which is the longest part of the anchor, the two arms, at the end of which are the two flooks or flukes, by some called the palms, which with their barbs fasten into the ground, and the flock, which is a long piece of wood fastened across the beam near the ring, and serving to guide the flukes in a direction perpendicular to the surface of the ground; so that one of them sinks into it by its own weight as soon as it falls, and is still preserved steadily in that position by the flock, which, together with the shank, lies flat on the bottom. In this situation it must necessarily sustain a great effort before it can be dragged through the earth horizontally. Should the anchor be displaced, it is said, in the sea phrase, "to come home."

The several parts of the anchor above enumerated bear the following proportions:—The length of the arm, from the inside of the throat to the bill, is the distance marked on the shank for the trend, taken from the inside of the throat; and three times that is the length of the shank from the tip of the crown; and the shank, from the tip of the crown to the centre of the ring, is the length of the iron stock; when made, the two arms, from the inside of the throat to the extremity of the bill, should form an arc of a circle containing 120 degrees.

The labour of raising the anchor when a chain-cable is employed, has been considerably diminished by a patent apparatus lately manufactured by Mr. Bailey of Holborn. It consists in the use of a small lever, which seizing on each link of the chain in succession, tends effectually to prevent its return, and enables a smaller number of men to effect the elevation than by the ordinary process.

ANCHYLOSIS; a stiffness or immobility of the joints. The existence of the disease is obvious to the eye. It is often connected with deformities of the limbs, and, in the anchylosis of the little bones of the ear, with deafness; in that of the joint of the lower jaw, with inability of chewing. Anchylosis may occasion the decaying of a limb, bleedings, aneurisms, &c., and may even become fatal. In the beginning of these diseases, the patient usually suffers pain in the limbs, a more or less audible rustling in moving the joint affected, a feeling of weakness and inability of directing the limb as it could be done in a state of health. An anchylosis usually arises from several causes, and afflicts sometimes the whole body, at other times one limb only. The anchylosis is sometimes constitutional; old people are more subject to it than young, and the male sex than the female. The real anchylosis is incurable. Excessive indulgence in animal passion may contribute to this disease; but it is, for the most part, the result of inflammation in the membrane lining the joints.

ANDANTE, in *Music*, denotes a time somewhat slow, and a performance distinct and exact, gentle and soothing. Andantino stands between andante and allegretto, at least according to the common notion; some assert that andantino implies a little slower motion than andante. The andante requires a delicate performance.

ANDROIDES, in *Mechanics*, an automaton in the form of a man. Vaucansons' *flute-player* may be considered as the most curious mechanical figure of which any correct account has been preserved. There is an interesting paper in the *Memoirs of the French Academy*, furnished by the artist himself, and he thus describes the apparatus:—The figure was about five feet six inches high, and was placed upon an elevated square pedestal. The air entered the body by three separate pipes, into which it was conveyed by nine pairs of bellows, which expanded and contracted in regular succession by means of an axis of steel turned by the machine. The three tubes which conveyed the air from the bellows, after passing through the lower extremities of the figure, united at the chest; and ascending from thence to the mouth, passed through two artificial lips. Within the cavity of the mouth was a small moveable tongue, which

by its motion at proper intervals admitted or intercepted the air in its passage to the flute. The fingers, lips, and tongue derived their specific movements from a steel cylinder turned by clock-work. The cylinder was divided into fifteen equal parts, which by means of pegs pressing upon a like number of levers, caused the other extremities to ascend. Seven of these levers directed the fingers, having rods and chains fixed to their ascending extremities; which being attached to the fingers, made them to ascend in proportion as the other extremity was pressed down by the motion of the cylinders, and vice versa. Three of the levers served to regulate the ingress of the air, being so contrived as to open and shut by means of valves the communication between the lips and reservoir, so that more or less strength might be given, and a higher or lower note produced as occasion required.

The lips were directed by four similar levers; one of which opened them to give the air a freer passage; another contracted them; a third drew them backward, and the fourth pushed them forward. The remaining lever was employed in the direction of the tongue, which by its motion shut or opened the mouth of the flute. The varied and successive motions performed by this ingenious androides were regulated by a contrivance no less simple than efficacious. The axis of the steel cylinder or barrel was terminated by an endless screw composed of twelve threads, above which was placed a small arm of copper with a steel stud made to fit the threads of the worm, which by its vertical motion was continually pushed forward. Hence, if a lever was moved by a peg placed on the cylinder, in any one revolution, it could not be moved by the same peg in the succeeding revolution in consequence of the lateral motion communicated by the worm. By this means the size of the barrel was considerably reduced; and the statue not only poured forth a varied selection of instrumental harmony, but exhibited all the evolutions of the most graceful performer.

Anemometer. An instrument for measuring the force and velocity of the wind. For this purpose a variety of contrivances have been suggested, many of which display no inconsiderable share of ingenuity. It has been proposed to suspend a rod, in the manner of a pendulum, with a flat board instead of a ball at its lower extremity. It is obvious, that when the wind impinges upon such a board, it will, according to its strength, force it more or less out of a vertical position, and therefore the angle of deviation will be the measure of that strength. Another contrivance resembles a small windmill, by the number of the revolutions of which, in a given time, the result desired may be obtained. Instruments have even been described, which express upon paper, not only the several winds that have blown during the space of twenty-four hours, but at what hour they began and ended, with the strength and velocity of each; but they are much too complicated for general use.

Anemoscope. Every contrivance which indicates the direction of the wind. The vane upon towers and roofs is the simplest of all anemoscopes. There are also some, where the vane turns a moveable spindle, which descends through the roof to the chamber where the observation is to be made. On the ceiling of this apartment a compass-card is fixed, and, whilst the wind turns the vane together with the spindle, an index fixed below points out the direction of the wind on the card. Some are so made as, even in the absence of the observer, to note down the changes of the wind. Among the most perfect of this kind, is that of Professor Moscati, and of the Cavalier Marsilio Landriani.

Aneurism. The swelling of an artery, or the dilatation and expansion of some part of an artery. This is the true aneurism. There is also a spurious kind of aneurism, when the rupture or puncture of an artery is followed by an extravasation of blood in the cellular membrane. If the external membrane of the artery is injured, and the internal membrane protrudes through, and forms a sac, it is called *mixed aneurism*. Lastly, there is the varicose aneurism, the tumour of the artery, when, in bleeding, the vein has been entirely cut through, and at the same time the upper side of an artery beneath has been perforated, so that its blood is pressed into the vein. The genuine aneurisms arise partly from the too violent motion of the blood, partly from a preternatural debility of the membranes of the artery, which is sometimes constitutional. They are, therefore, more frequent in the great branches of the arteries; in particular, in the vicinity of the heart, in the arch of the aorta, and in the extremities, for instance, in the ham and at the ribs, where the arteries are exposed to frequent injuries by stretching, violent bodily exertions, thrusts, falls, and contusions. They may, however, be occasioned also, especially the internal ones, by diseases, violent ebullitions of the blood, by the use of ardent spirits, by vehement passions and emotions, particularly by anger: in such cases the arteries may be ruptured, and sudden death produced. The external aneurisms are either healed by continued pressure on the swelling, or by an operation, in which the artery is laid bare, and tied above the swelling, so as to prevent the flow of the blood into the sac of the aneurism, which contracts by degrees. Sometimes the ligature is applied both above and below the aneurism.

Angle. See Geometry.

Animal Heat is that property of all animals by means of which they preserve a certain temperature, which is quite independent of that of the medium by which they are surrounded, and appears rather to be in proportion to the degree of sensibility and irritability possessed by them. It is greatest in birds. The more free and independent the animal is, the more uniform is its temperature. On this account, the human species preserves a temperature nearly equal, about 96—100° Fah., in the frozen regions at the pole, and beneath the equator; and on this account, too, the heat of the human body remains the same when exposed to the most extreme degrees of temperature; in fact, cold at first rather elevates, and extreme heat rather depresses the temperature of the human body. Fordyce and Blagden endured the temperature of an oven heated almost to redness, and two girls in France entered a baker's oven heated to 269° Fah., in which fruits were soon dried up, and water boiled. A Spaniard, Francisco Martinez by name exhibited himself, a short time since at Paris, in a stove heated to 279° of Fah., and threw himself, immediately after, into cold water. Blagden was exposed in an oven to a heat of 257°, in which water boiled, though covered with oil. There is also a remarkable instance of a similar endurance of heat by the *convulsionnaires*, as they were called, upon the grave of St. Medardus, in France. A certificate signed by

several eye-witnesses, among whom were Armand, Arouet, the brother of Voltaire, and a Protestant nobleman from Perth, states that a woman named la Sonet, surnamed the *salamander*, lay upon a fire nine minutes at a time, which was repeated four times within two hours, making in all, thirty-six minutes, during which time fifteen sticks of wood were consumed. The correctness of the fact stated is allowed even by those opposed to the abuses in which it originated. The flames sometimes united over the woman, who seemed to sleep; and the whole miracle is to be attributed to the insensibility of the skin and nerves, occasioned by a fit of religious insanity. These facts are the results of a law of all living substances, viz. that the temperature of the living body cannot be raised above certain limits, which nature has fixed. There is also an increased flow of perspiration, by means of which the heat of the body is carried off. The extreme degrees of cold which are constantly endured by the human frame without injury are well known, and are to be explained only by this power in the living body to generate and preserve its own heat. The greater the irritability of individuals, whether from age, sex, or peculiarity of constitution, the greater the warmth of the body: it seems also to depend, in part, upon the quickness of the circulation of the blood: thus children and small animals, whose circulation is lively, feel the cold least. The heat and the power of preserving it differ also in the different parts of the body; those appearing to be warmest in which there is the most copious supply of blood, as the brain, the head and neck, the lungs and central parts of the body. We see also, that when the irritability of the body, or of any part of it, is particularly increased, the heat of the part undergoes a similar change. Increased activity and motion of the body, as in walking, running, &c., and diseases of increased excitement, as fever and inflammation, produce a similar increase in the temperature of the body. All this justifies the conclusion, that animal heat depends chiefly upon the irritability of the body, and is thus most intimately connected with the state of the nervous system. This view is confirmed by the late experiments of Brodie, who ascribed this power of the living body to the influence of the brain. He destroyed the brain of a rabbit, and kept up the respiration by artificial means; but the heat of the animal regularly diminished.

Animal Life. Life, in the earlier periods of scientific knowledge, was attributed only to animals. With the progress of science, however, it was extended to plants; and man, who had been hitherto regarded as a distinct order of being, was now considered as but a higher animal, intimately connected with the whole chain of the organized world. The great discoveries in chemistry, magnetism, electricity, and galvanism, have shown that those elements and principles, on which rest the laws of life, pervade nature in the most various forms and combinations; that there is no harsh and abrupt distinction between the animate world and the inanimate, but, on the contrary, an intimate connexion between the energy which makes the crystallizing mineral follow the law of the strictest regularity, or the stone fall from the height, and that which makes the heart of man beat. The difficulty of defining animal life has, therefore, been greatly increased. What is animal life? What constitutes an animal? Since mankind began to cultivate philosophy, they have sought in vain for a definition of life. It would require much more metaphysical discussion, to enter at all satisfactorily into this subject, than the character of the present work allows: and we are constrained to offer the reader only the following remarks on this most interesting subject.—Linnæus defines an animal an organized, living, and sentient being. An animal is indeed organized; but are not vegetables organized also? Animals are endowed with sensation; but are all, without exception? and do not some plants possess this faculty? Locomotion is not a more certain characteristic of animals than life or irritability, for many animals are destitute of this power, and vegetate like plants, the images of torpidity and insensibility. Neither are the chemical characters of animal substances more distinct; animals are chiefly composed of azote, and vegetables of carbon; but, among the latter, some are, like the former, composed principally of azote. In whatever point of view we consider these two kingdoms of nature, we find them blended in so many ways, and separated from each other by such imperceptible gradations, that it is impossible to draw a line, at which we can affirm that animal life ends, and the vegetable begins.

Animal Magnetism. See Magnetism.

Animal Matter is the protection, the residence, and the visible form of animal life. The simple elementary substances are combined by the powers of life, according to the objects for which it was destined, into various animal substances, falling naturally under certain divisions, which all, however, in some respects, comprehend each other. They may be enumerated under two heads, fluids and solids. The first of these have no distinct form or organization, and yet possess properties, by means of which, when acted upon by the vital powers, they are capable of forming all the various organs of the body; and it is surely a most unnatural view of them to regard them as destitute of life. In the following list of animal fluids, which, in the processes of life, pass constantly the one into the other, we find all the fluid parts or kinds of animal matter: they are chyme, chyle, lymph, venous and arterial blood, and the various secreted and excreted fluids. The second division comprehends all the solid parts of the animal frame, both hard and soft, and are of nearly the same essential structure in all animals, although variously arranged, according to their species. A minute description of all these belongs to anatomy; we shall merely enumerate them. They appear in the form of; 1, bones, constituting the basis, the frame of the animal, and found in all animals till we come to shell-fish (whose shells may be even regarded as external bones), and to still inferior animals, possessing no substitute for bones; 2, ligaments and fibrous membranes, connecting and covering them; 3, muscles which move them, and place the body and its limbs at the command of the animal; 4, fat and marrow, which soften and lubricate all the various parts of the body; 5, nervous or medullary matter constituting the brain and nerves, in which the vital power seems more particularly to reside; 6, the cellular substance, or membrane, which pervades all parts of the frame, and serves to connect them, and to furnish with the fat, which fills its cells, a soft bed for the vessels, nerves, &c.; 7, the mucous membranes, lining the whole body, from the nose and mouth to the parts at which all evacuations take place, and thus coating the mouth, throat, lungs, stomach, and bowels, in which the important func-

tions of digestion and respiration are performed; 8, the serous membranes, which line all the large cavities, and which, by the soft fluid that always moistens their surface, render easy the motion of all the internal organs upon each other; 9, the vascular system, or vessels of all descriptions, conveying the blood to all the organs of the body, and returning it from them to the heart and lungs,; and 10, the glandular system, by means of which various fluids important to life are separated from the blood, or rather formed from it by a new composition of its original elements. "These several classes of animal matter comprehend all the various forms in which it appears in all animals of all kinds; the heart of a frog and of a philosopher being composed of similar muscular fibres, and their brains of similar nervous matter." These obvious component parts of animals are, however, separable by the art of the chemist into more simple and ultimate elements. The following are all that are at present known to exist, and of these some are peculiar to animals, while others enter, more or less, into the composition of all parts of the creation. They are, 1, iron, which is found chiefly in the blood, in the state of an oxide; 2, lime, which enters largely into the composition of bones, shells, &c.; 3, silex, in the enamel of the teeth; 4, water, which gives their liquid character to all the animal fluids; 5, air which is found, mixed with watery vapour, in all the cavities of the body; 6, soda, united with various acids, in all the various fluids of the body; 7, ammonia, in the perspiration, urine, &c.; 8, sulphur; 9, phosphorus, in the bones, &c.; 10, carbon; 11, various acids, as the phosphoric, muriatic, uric, lactic, formic, &c., which are found, variously combined, in most of the solid and fluid parts of the body; 12, gelatin, or glue; 13, albumen, constituting the chief part of the transparent and colourless membranes, and the fluids which moisten them; 14, fibrin, constituting the basis of all the muscles, ligaments, &c., and the most important ingredient in the composition of the blood. Most of these substances are again susceptible of still farther analysis, by which they may be resolved into the simple gases, as nitrogen, hydrogen, oxygen, &c.; so that it appears that the ultimate elements of all parts of the visible world are nearly the same in their essential character.

ANKER, a liquid measure of about thirty gallons,

ANNEALING, or NEALING, as it is called by the workmen, is a process particularly employed in the glass-houses, and consists in putting the glass vessels, as soon as they are formed, and while they are yet hot, into a furnace or oven, not so hot as to remelt them, in which they are suffered to cool gradually. This is found to prevent their breaking so easily as they otherwise would, particularly on exposure to heat. Unannealed glass, when broken, often flies into powder, with great violence, and in general it is in more danger of breaking from a very slight stroke than from one of considerable force. An unannealed glass vessel will often resist the effect of a pistol-bullet dropped into it; yet a grain of sand, falling into it, will make it burst into small fragments, and, which is very curious, it will often not burst until several minutes after being struck. The same phenomena are still more strikingly seen in glass-drops or tears: they are globular at one end, and taper to a small tail at the other: they are the drops which fall from the melted mass of glass on the rods, on which the bottles are made, into the tubs of water which are used in the work. Those which remain entire, after having fallen into the water, show the properties of unannealed glass in the highest degree. They will bear a smart stroke on the thick end, but if the small tail is broken, they burst into powder, with a loud explosion. The reason of this singular fact is differently given. A similar process is used for rendering cast-iron vessels less brittle.

ANNUITIES are periodical payments of money, amounting to a certain annual sum, and continuing either a certain number of years, as 10, 20, or 100, or for an uncertain period, to be determined by a particular event, as the death of the annuitant, or that of the party liable to pay the annuity, or of some other person, or indefinitely; and these last are called *perpetual* annuites. The payments are made at the end of each year, or semi-annually, or at the end of every quarter, or at other periods, according to the agreement upon which the annuity arises; and where it is liable to cease upon the happening of an event, the time of the occurrence of which is uncertain, as the death of a person, and such event happens after the expiration of a part of the time between one payment and another, neither the annuitant nor his heirs will be entitled to any proportional part of a payment for such time, unless some express provision is made for this purpose in the contract. The probability of the loss of such fractional part is to be taken into consideration in estimating the present value of the annuity; if the life in question is, according to the tables of longevity, good for 5½ years, an annuity for such life is worth more than if it were good for only just 5 years, since the probability of its continuing 6 years is greater. As an annuity is usually raised by the present payment of a certain sum, as a consideration whereby the party making the payment, or, some other person named by him, becomes entitled to an annual, semi-annual, quarterly, or other periodical payment of a certain sum, for a stipulated number of years, or for a period to be determined by the happening of a certain event; the rules and principles by which this present value is to be computed have been the subjects of much scientific investigation. The present value of a perpetual annuity is evidently a sum of money that will yield an interest equal to the annuity, and payable at the same periods; and an annuity of this description, payable quarterly, will evidently be of greater value than one of the same amount payable annually, since the annuitant has the additional advantage of the interest on three of the quarterly payments, until the expiration of the year; or, in other words, it requires a greater present capital to be put at interest, to yield a given sum per annum payable quarterly, than to yield the same annual sum, payable at the end of each year. The present value of an annuity for a limited period, is a sum which, if put at interest, will at the end of that period give an amount equal to the sum of all the payments of the annuity and interest; and, accordingly, if it be proposed to invest a certain sum of money in the purchase of an annuity for a given number of years, the comparative value of the two may be precisely estimated, the rate of interest being given. But annuities for uncertain periods, and particularly life annuities, are more frequent, and the value of the annuity is computed according to the probable duration of the life by which it is limited. Many such annuities are granted for public services. But life annuities are often

created by contract, whereby the government or a private annuity office agrees, for a certain sum advanced by the purchaser, to pay a certain sum annually, in yearly, quarterly, or other periodical payments, to the person advancing the money or some other annuitants named by him, during the life of the annuitant; or the annuity is granted to the annuitant, his heirs and assigns, during the life of some other person, or during two or more joint lives, or during the life of the longest liver or survivor among a number of persons named in the act or agreement whereby the annuity is raised. Such annuities are usually made transferable, and are sold and purchased in the market as a species of public stocks. When granted by a government, they are generally one mode of raising loans; when created by a contract with a private corporation or company, their object usually is, to give the annuitant the use, during his life, not only of the income of his capital, but of the capital itself. If a person, having a certain capital, and intending to spend this capital and the income of it during his own life, and leave no part to his heirs, could know precisely how long he should live, he might lend this capital at a certain rate during his life, and by taking every year, besides the interest, a certain amount of the capital, he might secure the same annual amount for his support during his life, in such manner that he should have the same sum to spend every year, and consume precisely his whole capital during his life. But, since he does not know how long he is to live, he agrees with the government, or an annuity office, to take the risk of the duration of his life, and pay him a certain annuity during his life, in exchange for the capital which he proposes to invest in this way. The probable duration of his life, therefore, becomes a subject of computation; and, for the purpose of making this calculation, tables of longevity are made, by noting the proportions of deaths, at certain ages, in the same country or district. An annuity guaranteed by a pledge of real estate is worth more than one of the same amount resting upon the mere promise of a government or private company. Accordingly, for the purpose of raising money upon better terms, that is, of selling the annuity for a greater present value, some of the governments of Europe have occasionally pledged their domains or the income of certain taxes, to secure the payment of the annuities. For the theory of annuities see INTEREST.

ANODYNES; means for soothing pain. As the pain may arise from very different causes, the means for counteracting it must be very different. Thus, for instance, a pain may be produced by inflammation; and, in this case, cooling means, lukewarm poultices, sometimes even bleeding or purging, will be the proper anodynes. At other times they should be of an inflammatory kind; for instance, in debility of the nerves, cramps, or spasms. in the stricter sense, we understand by anodynes such remedies as lessen the susceptibility to painful impressions, by diminishing the sensibility of the nerves. In early times, when the doctrine of poisons and antidotes was more attended to than any other part of medicine, the soothing quality of many simples was also more closely observed, and a particular class was formed in this way. As this property existed in a high degree in opium, then already in use, it not only obtained the first place in this class of simples, but the name *anodyne* was given to all mixtures containing it. The use of anodynes is proper only when the cause of pain cannot be removed, or not so soon as its violence requires, or where the pain itself is more injurious than the cause which produces it; as when it prevents a favourable crisis, by rendering the patient unable to sleep.

ANTIMONY is a bluish-white, brittle metal, of a scaly or foliated texture; it has a brilliant lustre, but becomes tarnished by exposure to the air; its specific gravity is 6.7. In this state, it is called the *regulus of antimony*, and is used as an ingredient in the manufacture of the best pewter, in some type-metal, and in casting leaden medallions. By exposure to heat it melts, and becoming oxydized, rises in dense white fumes, formerly called *argentine flowers of antimony*. Antimony forms with oxygen several oxides, with which the acids unite and give rise to numerous salts, the most important of which is the triple one, called *tartrate of potash and antimony*. It is manufactured in the large way by mixing one pound of glass of antimony with a pound of super-tartrate of potash, and boiling the mixture in a gallon of water for an hour: it is then filtered, evaporated, and set by to crystallize. Tartar emetic is the most generally used antimonial medicine; and it may be so managed as to produce either sweating, purging, or vomiting. Antimony is found in its metallic state in minute quantities in several countries, and in occasional mixture with ores of silver, lead, and copper; but it is from its combination with sulphur, in which state it occurs abundantly in Auvergne, Scotland, and Hungary, that the antimony of commerce is furnished. This mineral, the sulphuret of antimony, is found in compact, foliated, and radiated masses, as well as in distinct rhombic prisms. Its colour is a light lead-grey; it is dull, and often iridescent. Specific gravity, 4.3. It melts in the flame of a candle, and before the blow-pipe, on charcoal, is wholly evaporated, with a sulphureous odour. It is composed of antimony 72.86, and sulphur, 27.14, and in its composition exactly resembles the artificial compound which possesses the same properties. To obtain the crude antimony of commerce, the above ore is reduced to fragments, and put into large earthen pots, with holes in their bottoms, and these are inserted into other similar vessels; heat is applied to the upper ones, which causes the sulphuret of antimony to separate from its stony case, and flow into the lower vessels, which are kept cold; here it concretes into fibrous, crystalline masses, without having undergone any change in its nature during the process. In this condition, it constitutes the crude antimony of commerce. From this substance the regulus of antimony is prepared, by roasting the sulphuret of antimony in a reverberatory furnace, until it forms a grey oxide, 100 weight of which is afterwards mixed with 8 or 10 pounds of argal, or crude tartar, and smelted in large melting pots in a wind-furnace. It also affords, by calcination and subsequent fusion in earthen crucibles, the glass of antimony, which is of so much importance in the preparation of tartar emetic. The Kermes mineral, a popular medicine, is likewise prepared from the sulphuret of antimony, by boiling crude antimony and pearl-ashes; the Kermes mineral is deposited in the form of a purplish-brown powder. The supernatant liquid, on the addition of any acid, yields an orange sediment, called *golden sulphur of antimony*,

which is used by the calico-printers as a yellow dye.

ANTISEPTICS; remedies against putrefaction. The ancients thought it possible, by certain preparations, to resist a general tendency to putrefaction, which they supposed to exist in the system. The moderns have only attempted to prevent the affection of the sound by the mortified parts, by means of external applications, which favour their separation. We are indebted to chemistry for most of these remedies, which generally operate by absorbing the liquids and gases of the gangrenous parts. Among antiseptical substances, charcoal-powder has hitherto been one of the most esteemed, but the chloride of lime has been recently discovered to be much more efficacious in arresting the progress of putrefaction. Placed in contact with the affected parts, it destroys the offensive odour which they exhale, and prevents the extension of the corruption. The practitioner must adapt the treatment to particular circumstances: to inflammation he opposes bleeding, emollients, &c.; to weakness, nourishing food, tonics, &c.; at the same time with the local application of the antiseptic. Under the head of antiseptics we must not omit to notice the Pyroligneous Acid, which see.

ANTISPASMODIC; a name given to any thing which has the power of relieving the cramp. Antispasmodics are more accurately defined, medicines proper for the cure of spasms and convulsions. Opium, balsam of Peru, and the essential oils of many vegetables, are the most useful of this class of medicines.

ANTISYPHILITIC; a term applied to remedies used in cases of syphilis. They are almost numberless; and there exists, perhaps, not one substance in the three kingdoms of nature to which an antisyphilitic power has not been ascribed. The most efficacious are preparations of mercury, which is administered in a great variety of ways; sudoriferous vegetables, the combinations of which are also extremely numerous; and preparations of gold, particularly of the muriate of this metal.

ANVIL, a smith's utensil, serving to place the work on to be hammered or forged. The face, or uppermost surface of the anvil, must be very flat and smooth, without flaws, and so hard that a file will not touch it. At one end there is sometimes a pike, bickern or beak-iron, for the rounding of hollow work. The whole is usually mounted on a firm wooden block. Forged anvils are better than those of cast work, and the best have the upper part made of steel. Locksmiths have a smaller kind of anvil called the *stake*, which is moveable, and placed ordinarily on their work-bench. Its use is for setting small cold work straight, or to cut or punch on with the cold chissel or cold punch.

AORTA; the great artery which rises immediately out of the left ventricle of the heart. It is divided into two grand trunks, distinguished by the epithets *ascending* and *descending*. (See ARTERY.)

APHELION, the term employed to mark that part of the orbit of the earth, or any other planet, in which it is at the point remotest from the sun. This also applies to a satellite; for the moon has her aphelion as well as the planets.

APOGEE; that point in the orbit of the sun, or of a planet, which is at the greatest distance possible from the earth, in contradistinction to the point of greatest nearness, which is called the *perigee*. The ancient astronomers, regarding the earth as the centre of the system, paid particular attention to these points, which the moderns, making the sun the centre, change for the *aphelion* and *perihelion*.

APEPSIA; indigestion. Abstemiousness and excess are alike causes of indigestion. An over distension of the stomach may in some measure injure its proper tone; and long fasting, by inducing a bad quality in the juices secerned into the stomach, renders it feeble, and generates wind. Hard drinking, and any of the causes of an anorexy, also injure digestion.

APERIENTS, in the *Materia Medica*, an appellation given to such medicines as facilitate the circulation of the humours by removing obstructions. The five aperient roots of the shops are, smallage, fennel, asparagus, parsley, and butchers' broom.

APOPLEXY is the name applied to a disease which occurs very suddenly, as if a blow had been inflicted upon the head, and deprives the person of consciousness and voluntary motion, while the respiration and action of the heart continue, although much oppressed. In a complete apoplexy, the person falls suddenly, is unable to move his limbs or to speak, gives no proof of seeing, hearing, or feeling, and the breathing is stertorous or snoring, like that of a person in deep sleep. In a case of less violence, the symptoms are more moderate. Consciousness sometimes remains in part; some power of motion is retained upon one side, or in some parts at least; the speech is not entirely lost, but is only an unintelligible muttering of incoherent words. The immediate cause of this disease is some affection or injury of the brain, or of some portion of it; and it is most commonly produced by a fulness of blood in the head, either remaining in the blood-vessels, or poured out in or upon the brain, from their rupture in some part, and in sufficient quantity to exert considerable pressure upon that organ. As the state of the whole body depends much upon the sound condition of the brain and nerves, it is evident that such an unnatural state of these organs cannot continue long without danger to life. The termination and effects of the disease vary with the violence of the attack; and it is either fatal in a few hours, or after a few days, during which a degree of fever is often observed, or the patient recovers, entirely or with a weakness or lameness of one or more limbs. The immediate cause of the symptoms first occurring, and of those remotely subsequent, is not known with absolute certainty; but from the examination of the bodies of those who have died with this disease, or in whom death has been produced by mechanical injuries to the head, which have been attended by similar appearances; and from the entire similarity of the symptoms in persons whose brains are injured by the pressure of bones, or blood, or in whom the brain exposed by some wound is purposely compressed, &c., to the symptoms presented by apoplexy; there is scarcely room to doubt that genuine, complete apoplexy is produced by the pressure of blood (whether extravasated or not) upon the brain. This arises from the destruction of the equilibrium or balance of the circulation by various causes, by which an unnatural quantity of blood is forced into an otherwise healthy brain, or the brain and its vessels so weakened, that they are unable to sustain the pressure of the usual quantity of blood. Some of these causes operate directly upon the brain, as strong passions, hard study, exhaustion from fatigue,

&c.; others, indirectly, through the medium of the stomach, as when this disease is produced by indigestible food, &c. The disposition to it is sometimes hereditary, and is most usually found to accompany a short, full person, a short neck, and a system disposed to a too copious sanguification. It sometimes also occurs in people who are exhausted by old age, excessive labour or anxiety, and in these cases the brain seems to be too weak to perform its common functions, and the efforts required of it produce an injurious or destructive flow of blood to it. It will be readily conjectured from what has been said, that the cure of this disease is by no means easy, as the treatment must be accommodated to the various causes which may have produced it. It is at all times a disease of great danger, but by no means always fatal; and those affected by it sometimes recover as entirely as from any other complaint, although some lameness or defect of motion is apt to remain, either in the limbs, the organs of speech, the eyes or mouth, or some other part. A fatal result is to be anticipated when the consciousness and feeling are entirely lost; when the eye is insensible to light, and the pupil does not contract; when the patient cannot swallow, the respiration grows more laborious, and froth or blood appears at the mouth or nose. But if, on the contrary, the remedies used appear to afford relief, and produce a gradual diminution of the symptoms above described, a favourable result may be expected. Although an attack of apoplexy comes on for the most part suddenly and unexpectedly, yet it is often preceded by appearances which give warning of its approach These are a high colour of the whole face, giddiness or vertigo, sparks or flashes of light before the eyes, noises in the ears, bleeding at the nose, and pain in the head. The danger in such cases may most commonly be averted by bleeding and abstemious diet, to be continued till these symptoms are removed. When a person is unfortunately attacked by apoplexy, the first step should be to open the cravat and collar, so as to leave the neck free: if it be a short time after a meal, or if the last meal has been of an indigestible character, the stomach should be emptied by an emetic, or by tickling the throat with the finger, without waiting for a physician, and at the same time a vein or two should be opened, so as to produce a free flow of blood, which should be continued, if the face is flushed and red, till relief is obtained. Subsequent treatment will of course be directed by a medical attendant. Great care should be taken in such cases that no attempt is made to arouse the person by rubbing or any sort of stimulation, internal or external, as these can only do harm. Paralysis, or palsy, is sometimes a consequence of apoplexy, but it is more commonly produced by causes of a different character, and constitutes a different disease. (See PALSY.)

APPOGGIATO denotes in music, and particularly in song, a blended and not abrupt utterance of the tones; so that they insensibly glide and melt into each other without any perceptible break. It is from *apoggiare*, to lean on. Hence, also,

APPOGGIATURA, a small additional note of embellishment preceding the note to which it is attached, and taking away from the principal note a portion of its time.

APPROXIMATION; a term used in mathematics to signify a continual approach to a quantity required, when no process is known for arriving at it exactly. Although by such an approximation the exact value of a quantity cannot be discovered, yet in practice it may be found sufficiently correct; thus the diagonal of a square, whose sides are represented by unity, is $\sqrt{2}$, the exact value of which quantity cannot be obtained; but its approximate value may be substituted in the nicest calculations. This process is the basis of many calculations in pure and applied mathematics, and is of frequent use and great importance in all practical operations.

APSIDES. The orbits of the planets and comets are ellipses, in one of the foci of which is the sun. In the same way the satellites move round their planets. The nearest point of the ellipse from that focus, is the lower *apsis*, and is also called, in the orbits of the planets and comets, *perihelion*; the farthest point or the higher apsis is called *aphelion*. In the orbit of our moon, the corresponding terms are *perigee* and *apogee*. The straight line which joins the apsides, or the transverse axis of the ellipse, is called the *line of the apsides*. It moves slowly forward in the direction of the planet's course. Therefore, if the earth sets out from the apogee, it must make more than a whole revolution in its orbit before it returns to the same point. The time which it employs in so doing is sometimes called an *anomalistical year*. It is therefore longer than a tropical one.

AQUA FORTIS; nitric acid in a diluted state. (See ACID.)

AQUA MARINA. (See BERYL.)

AQUA REGIA. The name given by the alchemists to what is now called *nitro-muriatic acid*,—a mixture of nitric and muriatic acid, yellow, and possessing the power of readily dissolving gold, which neither possessed separately. (See ACID.)

AQUARIUS, the Water-carrier, in *Astronomy*, the eleventh sign in the zodiac, reckoning from Aries; from which also the eleventh part of the zodiac takes its name. The sun moves through Aquarius in the month of January.

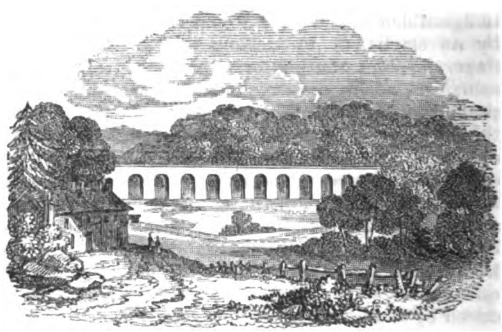
AQUA TINTA; the art of engraving on copper after the manner of Indian ink, by which happy imitations are made of figures that have been drawn with the pencil in Indian ink, bistre, sepia, &c., particularly those which are on a large scale. There are several sorts of it. In the first, after the outlines o the figure have been etched, finely powdered mastic (*colophonium*) is sifted over the plate, which is then warmed over coals, that the mastic may be melted. In this way insensible spaces are formed between the particles of mastic upon which the nitric acid is afterwards to act. The work then goes on as in the mezzo tinto, only that the scraper is used in this, and the pencil in that; and all the places where there is to be no work or shade are covered with a thick black varnish, on which the acid does not act. The nitric acid is now poured on, and left to stand as long as is necessary for the lightest shade—about five minutes. The light shades are now stopped out with varnish, and the acid allowed to act a second time, and this stopping out is continued till we come to the deepest shades, which are bit in last. This method is best for historical and architectural subjects; but in landscapes, in which the trees require more freedom of the pencil, the second is used. In this a good etching ground is spread over the plate, and covered by means of a hair-pencil, with oil of lavender or oil of turpentine, to which lamp-black is

sometimes added. The oil softens the ground, which may be wiped off with a fine linen cloth, leaving all the marks made with the pencil apparent on the copper. Then, as in the first process, fine mastic is sifted over the plate, melted in and etched. This operation may be repeated many times, according as there are more or fewer tints in the original. By a happy union of both sorts, this style of engraving is carried to a high degree of perfection, and is particularly adapted to express the colouring of the air, where large surfaces are often represented of one tint. In France and Switzerland, the *roulette* is used —a little wheel or roller of steel, with a rough surface and several prominences, which when it is rolled back and forth on the plate, deepen the excavations made by the acid. They have roulettes of all degrees of size and fineness, to make deeper or more shallow impressions on the plate. From time to time the particles separated by this process are removed with a scraper. The aqua tinta mode was first introduced a short time since into England and Germany; and the English, particularly since Gilpin brought the art into notice, have adorned their literary works in this manner.

Aqua Tofana; a poisonous liquid, which excited extraordinary attention at Naples at the end of the 17th and beginning of the 18th centuries, the history of which however is obscure. Tofana, a Sicilian woman, seems to have invented it. According to Lobat, after she had murdered many hundred men, she fled to a convent, although on the discovery of her guilt she was strangled. Keyssler, on the contrary, affirms that she was still alive in prison, 1730. The drink is described as a transparent, tasteless water, of which five or six drops are fatal, producing death slowly, without pain, inflammation, convulsions, or fever. Gradual decay of strength, disgust of life, want of appetite, and constant thirst, were the effects, which soon changed to an entire consumption. That the exact day of death can be predicted, is a mere fable. The strangest stories with regard to its composition have gone abroad. A solution of crystallized arsenic seems to have been the chief ingredient, to which something else was added, probably to conceal the presence of it.

Aqueduct (Latin, *aquæductus*); a conveyance of any kind made for conducting water. The Greeks did very little towards the construction of aqueducts and roads. The Romans, on the contrary, who were more persevering, and had abundant resources of men and money, made prodigious structures of both kinds. Some of the immense aqueducts of the Romans are still in use; some, in the state of ruins, are among the greatest ornaments of Italy. In other ancient countries, also, large aqueducts were built; under Sesostris, in Egypt; under Semiramis, in Babylonia; under Solomon and Hezekiah, among the Israelites. The consul Sextus Julius Frontinus, who had, under the emperor Nerva, the direction of the aqueducts, has written a treatise on this subject—*De Aquæductibus Urbis Romæ*—and is of opinion that they are the most distinguishing proofs of the grandeur of the empire. He mentions nine aqueducts, which had 1594 pipes of an inch and upwards in diameter. Aqueducts were either formed by erecting one or several rows of arcades across a valley, and making these arcades support one or more level canals; or by piercing through mountains, which would have interrupted the water-course. When the aqueduct was conveyed under the ground, there were openings at about every 240 feet. Some of the Roman aqueducts brought water from the distance of upwards of sixty miles, through rocks and mountains, and over valleys in places more than 190 feet high. The declivity of the aqueduct, according to Pliny, was 1 inch, and according to Vitruvius, ½ a foot in a hundred. The censor Appius Claudius Crassus Cœcus, the builder of the great road which was called after him, caused the first aqueduct to be built at Rome, the *Appia Aqua*. Frontinus, as we stated, mentions nine, Procopius 14, and P. Victor 24 aqueducts; some of which were one, some two, some even three stories high, and many miles long. In almost all countries where the Romans extended their conquests, aqueducts were built; thus we find the remains of them in France, Spain, and Asia. The principal Roman aqueducts now remaining are the *Aqua Virginia*, repaired by Pope Paul IV., and the *Aqua Felice*, constructed by Sextus V. In modern times, that of Segovia may be compared with the most admired works of antiquity. At a recent period, there remained 159 arcades, wholly consisting of enormous stones joined without mortar. Louis XIV. began an aqueduct, in 1684, near Maintenon, to carry water from the river Eure to Versailles; but the works were abandoned in 1688. This would have been, perhaps, the largest aqueduct in the world; the whole length being 60,000 fathoms, the bridge being 2070 fathoms in length, 220 feet high, and consisting of 632 arches.

Under this head we must not omit to notice Mr. Telford's great work, the aqueduct of Chirk in Denbighshire. It consists of ten arches, supported by pyramidical piers of stone, and extending about six hundred feet in length. The height of the central arch is about sixty-five feet above the level of the water. Chirk aqueduct is intended for carrying on the navigation of the Ellesmere canal, and is surrounded with some very beautiful and picturesque scenery. Its general effect is well given in the accompanying engraving.



Arabesque, or Arabesk, something done after the manner of the Arabians. *Arabesque, Grotesque*, and *Moresque*, are terms applied to paintings, ornaments of friezes, &c. where there are no human or animal figures, but which consists wholly of imaginary foliages, plants, or stalks. The term is derived from the circumstance that the Moors, Arabs, and other Mahometans only use these ornaments; their religion forbidding them to make any images or figures of men or other animals.

Arack, or Rack; a strong spirituous liquor,

distilled from rice, sugar-cane, or the juice of the cocoa-nut. The last, which is the best, comes from Batavia; the others, from Goa. At Goa, there are three kinds, single, double, and treble-distilled. The double is most sought, although weaker than the Batavian. By stat. 11 Geo. I. c. 30, arack may be seized on board a ship within the limits of any British port.

Aræometer. This instrument is more for curiosity than absolute utility. It was known to Archimedes, who used it for the same purpose as we employ the hydrometer. Some instruments, such as that employed by the French chemist Beaumè, and which is occasionally used in France under the name of *Aréometre de Beaumè*, consist of a small pear-shaped bulb, and a stem graduated in equal parts, which on immersion give the density of the fluid, by a reference to the scale.

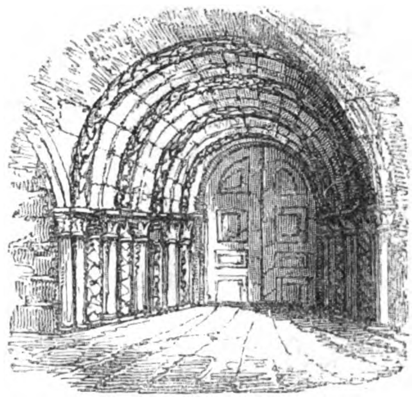
Arc, in *Geometry*, any part of the circumference of a circle or curved line, lying from one point to another, by which the quantity of the whole circle or line, or some other thing sought after, may be gathered.

Arch. A building formed of a segment of a circle, used for bridges, covering apertures, &c., supported by piers, columns, or abutments. The most usual denominations of arches are circular, elliptical, cycloidal, parabolical, hyperbolical, catenarian, equipollent, equilibrial, &c., according to their figure or quality. There are also semi-circular, semi-elliptical, segmental, and compound arches, of various denominations. Circular arches are of several kinds, according to the different parts of a circle. A simi-circular arch is composed of half a circle; a scheme, or segmental arch, is any segment less than a circle; and Gothic, or pointed arches, consist of two circular arcs eccentric, and joined in an angle at the top, each being one-third, or one-fourth, &c. of the whole circle. Elliptical arches are formed of a portion of an ellipsis, and are, in the opinion of some mathematicians, the best calculated for the construction of bridges, as they look bolder, are stronger, and require less materials and labour than the others. Cycloidal arches are constructed of the cycloidal curve, and reckoned, by Dr. Hutton, the best, after the ellipsis, for the above purpose. The learned Doctor reckons the circle next. And as to the others, the parabola, hyperbola, catenaria, &c., he says they should not be at all admitted into the construction of bridges of several arches; but may in some cases be used for a bridge of a single arch which is to rise very high, because then they are not much loaded on the haunches.

A popular view of the principal architectural forms of the arch, as leading to the date of any ancient edifice, will here be found of considerable use, and we cannot do better than quote some striking examples from a very valuable popular work, published by a branch of the Society for promoting Christian Knowledge.

The doors and windows of old English churches, generally, have pointed arches; and from the shape of these arches principally, though there are other minor distinctions, the age of the building may be most accurately inferred, as they have varied in height and width from age to age.

Before the introduction of the English or pointed arch, the circular or rounded arch was in use; and a few very beautiful examples of this kind of building still remain in different parts of the country. It is called Saxon or Norman, from its having prevailed during the reign of the Saxon and Norman kings in England. It commenced at the establishment of Christianity among the Saxons, in the 6th century, and continued to about the year 1135, in the reign of king Stephen. The entrance to the Temple Church, London; the Abbey Gate, Bristol; and the Church of Romsey in Hampshire, are in this style of architecture. The doors in this style are sometimes quite plain, and sometimes very richly carved. The accompanying engraving is from the Temple Church.

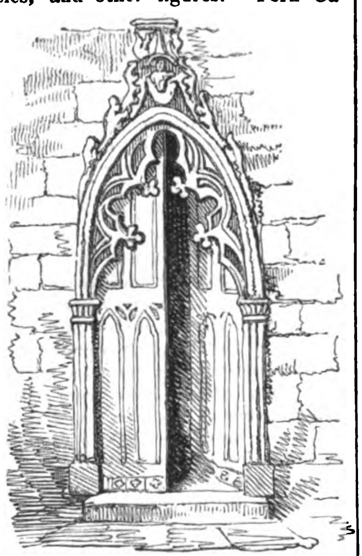


Between the reign of Stephen and that of Henry III., the circular arch began to diappear; and before the death of the latter monarch, gave way to the pointed arch. At first the two arches were intermixed; and the style was then called, *semi, or half-Norman.* Some suppose that the pointed arch was introduced from the Saracens, by the Crusaders to the Holy Land, and from this circumstance they call it the Saracenic arch; but the greater number of persons imagine it to have arisen from the accidental intersection of several rounded arches with each other. That this will produce pointed arches of different widths and heights, according to the points of intersection, may easily be shown by placing two hoops or rings across each other, allowing one point of the hoops or rings to rest upon a floor or table. The crossings of the boughs of trees in an avenue also afford a familiar illustration of the same fact. In the Temple Church the two arches may be found united, and other specimens may be seen in the Church of St. Cross near Winchester; the ruins of Buildwas Abbey, Shropshire; Fountains Abbey, Rievaulx Abbey, and Roche Abbey, in Yorkshire.

When the circular arch totally disappeared in 1220, the *Early English Style* commenced. The windows of this style were at first very narrow in comparison with their height: they were called lancet-shaped, and were considered very elegant: two or three were frequently seen together, connected by dripstones. In a short time, however, the windows became wider, and divisions and ornaments were introduced. Sometimes the same window was divided into several lights, and frequently finished at the top by a light in the form of a lozenge, circle, trefoil, or other ornament. A specimen of this kind may be seen in the beautiful church of St. Saviour's, Southwark, which has lately been thrown open to view by the improvements connected with the erection of the New London

Bridge, and another and a very beautiful example in the "Lady Chapel," which is in course of repair. With reference to the formation of this arch, it is curious to examine the extreme accuracy with which the masonry is connected at the springing of the arch. It is in this respect much superior to that of a later period. The door of St. Mary's, Lincoln, is also in this style, of which we subjoin an example.

About the year 1300, the architecture became more ornamental, and from this circumstance received the name of the *Decorated English Style*, which is considered the most beautiful for ecclesiastical buildings. The windows of this style are very easily distinguished: they are large and wide, and are divided into several lights by mullions, which are upright or perpendicular narrow columns, branching out at the top into tracery of various forms, such as trefoils, circles, and other figures. York Cathedral affords a fine specimen of this sort of architecture, and there is a beautiful window of the same style in the south transept of Chichester Cathedral. The West front of that of Exeter is another specimen, and the door-way of Lincoln Cathedral is in this style, of which we have a delineation in the annexed engraving.



The transition from the *Decorated* to the *Florid* or *Perpendicular Style*, was very gradual. Ornament after ornament was added, till simplicity disappeared beneath the extravagant additions; and about the year 1380, the architecture became so overloaded and profuse, that it obtained the title of ***Florid***, which by some persons is called the ***Perpendicular***, because the lines of division run in upright or perpendicular lines from top to bottom, which is not the case in any other style. King's College Chapel, Cambridge, begun in the reign of Henry VI., though not finished till some time after; Gloucester Cathedral; Henry VII.'s Chapel at Westminster; St. George's Chapel at Windsor; Wrexham Church, Denbighshire; and the Chapel on the Bridge at Wakefield, Yorkshire, are all of this character. Many small country churches are built in this style; and their size not admitting of much ornament, they are distinguished from structures of a later date by mouldings running round their arches, and generally by a square head over the obtuse-pointed arch of the door. A peculiar ornament of this style is a flower of four leaves, called from the family reigning at that period, the Tudor flower.

Architecture. This beautiful and important branch of the fine arts, combines within itself painting, sculpture, building, and some of the higher portions of mathematical science. Michael Angelo Buonarotti, the great founder of modern architecture, possessed these attainments in a very eminent degree, and was consequently enabled to leave to posterity a monument of his art, unequalled by any but that of our own countryman Wren. And if we go back to a still earlier period, we shall find that most of the great edifices of antiquity required as intimate an acquaintance with the exact sciences, as with the merely ornamental branches of design. Of the paramount importance of architecture little need be said, whether we consider it, as some have done, as a mechanical science, sheltering beneath its ample wing the several employments of masons, carpenters, smiths, and all those artizans whom modern refinement has rendered necessary for the enjoyment of life, or as a fine art, exercising the highest powers of the human mind, and becoming the parent and preserver of painting and sculpture, whose very existence may be said to depend upon it.

The history and progressive improvements in architecture will in the first instance engage our attention, and we may then with advantage to the reader furnish a series of popular illustrations of the main distinguishing features of the various "styles" which have been resorted to from the earliest recorded period.

Whatever celebrity the wonders of Babylon attained amongst the ancients, no remains of them have come down to us, and it is the massive edifices of Egypt, built apparently rather for eternity than time, that now excite our admiration as the most ancient as well as stupendous structures existing upon earth. We must not, at this period, omit to notice the remains of Indian and Mexican greatness. But for the splendid ruins at Delhi and Agra, and that most singular specimen in the island of Elephanta, we should scarcely have known of the existence of civilization among the ancient Hindoos; and the aborigines of Mexico were regarded as little better than savages, before the late discoveries by Mr. Bullock. The dates of these buildings are wholly unknown; but from the general similarity they bear to those of Egypt, it is supposed they are of at least equal antiquity. About the same general date may also be classed the architecture of the Hebrews, or, as more properly characterized, the Phœnician style, the greatest mo-

nument of which was the far-famed temple of Solomon. The description of this in the sacred text, will be found on an accurate consideration, to bear great resemblance to that of many of the Egyptian temples. From the Egyptians, the art, such as it was, was learned by the Greeks; but under the protection of that extraordinary people it reached a perfection unheard of before, and, in its peculiar style, unequalled since. The earliest edifices of Greece, however, were by no means remarkable for beauty, the temples in the time of Homer, being little better than rude huts, sheltered, if sheltered at all, by branches of laurel and other trees.

On the decline of Greece, and its conquest by the Romans, the art appears to have been transferred to the conquerors; but among that hardy and warlike race, it made little progress before the age of Augustus. Under the protection of that munificent monarch it rapidly attained to almost as great perfection as in the favoured country of the arts, and the "eternal city" owes much of its present estimation to the noble structures erected by him and his successors. With Rome, however, the art decayed, and was overwhelmed in the general confusion and oblivion of learning, art, and science.

The attention of the Saxons in our own country, probably about the eight century, was excited by the remains of edifices raised by the Romans during their residence in England. These, in their newly-erected churches, they aspired to imitate, but their workmen, ignorant of the principles which guided the architects of those splendid ruins, produced only the general outlines of their patterns, and those clumsy forms continued to be practised with little alteration till the end of the twelfth century. But now, as the tumult excited by the invasion subsided, and the genius of the nation improved, a taste for the fine arts began to show itself, and architecture assumed a different and novel aspect. Instead of tamely treading in the steps of their predecessors, the architects of those times devised a style as scientific as it was grand, and as beautiful as new.

But we must not, while eulogizing those who have adorned our own country with such admirable structures, forget the merits of their contemporaries on the continent · of these it seems to be generally acknowledged, that the French preceded us in point of time, and the Germans excelled us in the size of their edifices : yet no one, on comparing with an impartial eye the several buildings, will hesitate to allow, that in purity of style, variety of design, and delicacy of execution, the English cathedral, and other churches, are not surpassed by those of any nation in Europe; and it is a remarkable fact, that English architects and workmen were employed in many of the finest works on the continent.

We must now turn our attention to Italy : it is worthy of notice, that the Gothic style never came to so great perfection in this country as in the neighbouring nations. Perhaps this was owing to the number of Roman buildings remaining amongst them, and the liberal use they made of their fragments, which is shown even in the finest specimen they possess, Milan cathedral. It is not therefore surprising that the Italians should be the first to reject the style altogether. Indeed, there were instances, in the darkest times, of recurrence to the purer models of antiquity, but these met not the public taste, and were born only to die.

The church of the Apostles at Florence, which was built by Charlemagne in A. D. 805, appears to have been the first effort to revive the forgotten architecture of ancient times, and possessed so much merit, that Bruneleschi, 600 years afterwards, disdained not to accept it as a lesson in one of his own edifices. Two hundred years passed away, and the church of St. Miniate, in the same illustrious city, momentarily recalled from its apparent oblivion this elegant style. The same period again elapsed, and the genius of Cimabue arose to dispel the mists which had so long enveloped the arts of his country. His attention, though principally devoted to painting, was like that of most of the great artists of his time, occasionally turned to the sister arts, and it was partly by his instruction that Arnolpho Lapo became the wonder of the age. The father of this eminent architect, James, was a German by birth, but resided at Florence, where he built the convent of St. Francis, and received the surname of Lapo from the citizens for his skill in architecture. The son, Arnolpho, built the cathedral of St. Marie del Fiore, the largest church in Christendom next to St. Peter's. Although this was principally in the Tedeschi style (the appellation given by the Italians to the debased Gothic of their country), yet so uncommon was the skill displayed in its erection, that the dome being left unfinished by the death of the architect, a century and half elapsed before another could be found to raise it. This was Bruneleschi, who died in the year 1444, and may be considered as the reviver of the classical architecture. His principal work was the Palace Pitti in his native city.

It might have been expected that Rome, which possessed so many fine specimens, would have been the first to show to the world her sense of their value, by encouraging their imitation; but it was not till the middle of the fifteenth century that Pope Nicholas the Fifth showed the first symptoms of reviving taste, by the encouragement of Leon Baptista Alberti (the earliest modern writer on architecture) and Bernardo Rosilini. These, however, were principally employed in repairs, and the erection of fountains, and to Bramante must we concede the honour of being the first who materially adorned this city by his designs. With the then Pope, the memorable Julius the Second, he was much in favour, and it is supposed that it is in a considerable degree owing to this architect that that magnificent pontiff formed the resolution of rebuilding the cathedral of St. Peter in a style suited to the importance and magnificence of the see. In the lifetime of Bramante, however, little was done of this stupendous work; for such was the conception of the architect's collossal imagination, that, although in its present state its section is about double that of St. Paul's at London, it was reduced by his successor, Balthazar Peruzzi; and more considerably by the next who took it in hand, Antonio di San Gallo. These architects, however, while they exerted their talents on paper, proceeded little with the work, and it was left for the sublime genius of Michael Angelo permanently to fix the design of this masterpiece of art, and prince of Christian churches. The edifice, as we now see it, is principally his, except the front, which is considered inferior to the other parts. This work completed, the example thus set by its principal cities was quickly followed in all parts of Italy, which thus gave employment to the talents of Pirro Ligorio, Vignola, Dominico Fontana, Michael San

Michael, Falconetti, Sansovino, Serlio, Barbaro, Scamozzi, and Palladio.

The pure taste which characterized most of these architects, however, was not of long duration. The celebrated artist, Bernini, was one of the first who violated their precepts. He was educated at Rome as an architect and sculptor, and it is related of him, that returning to his native city late in life, with a large fortune, the product of his talents, he was much struck with some of his early works of the school of Michael Angelo and Palladio. He could not but contrast their elegance with the affected graces of the style he had given into, "but," exclaimed he, "had I continued in this manner, I should not have been what I am now." Contemporary with Bernini was Borromini, who was yet more depraved, and was so jealous of the former's fame, that he stabbed himself. After these, Italy cannot boast of any great architects, and we must now return to our native country, as more interesting to its inhabitants, and indeed of more importance in our history than France, or the other nations of Europe.

From the time of Edward the Third, there was a visible decline in the style of English architecture, which lost itself in a profusion of ornaments, more attention being paid to the details, than to the general forms of the buildings. By the time of Henry the Eighth this increased to a great extent, and the chapel erected by his father at Westminster was one of the last buildings which showed any taste in the style. This depraved manner naturally excited disgust in the minds of those persons who had seen the purer style then prevailing in Italy, which, as might be expected, they endeavoured to introduce. The nation, however, had been too long accustomed to the Gothic readily to surrender it, and during the reigns of Elizabeth and James, the mixture of, or compromise between, these styles produced a most barbarous result. But this could not last long: the prejudices of the people in the course of time gave way, and Italian architecture in all its purity was first executed in this country by Inigo Jones.

The father of modern English architecture was born about 1572, and died in 1652. At the expense either of the Earl of Pembroke or the Earl of Arundel, he travelled into Italy, and from an examination of the elegant buildings in that country, both of ancient and modern erection, he imbibed a taste for architecture, which he put in practice with great success on his return to England. His first work in this country was the interior of the church of St. Catherine Cree in London, and his most considerable design, the projected palace of Whitehall, the part of which that is executed, the Banquetting-house, is barely one-fiftieth part of that magnificent idea. After the death of Jones no considerable architect appeared, till the talents of Sir Christopher Wren (before that time devoted to philosophy and general learning) were called to the aid of the languishing art. He was born in the year 1632, and died at the age of ninety-one, in 1723, after being, in his eighty-sixth year, unfairly dismissed from the office of surveyor-general, which he had held with unparalleled ability fifty-one years. When that temporarily disastrous, yet permanently useful event, the fire of London, occurred, this great man was almost solely employed in rebuilding the numerous public edifices destroyed by the conflagration, and chiefly the cathedral of St. Paul; his execution of which arduous task, whatever be the objections raised against parts of it, by the taste of some, and the jealousy of others, remains a lasting monument of his genius in decorative, and unexampled skill in constructive architecture.

Before the death of Wren appeared Sir John Vanburgh, who was employed by the nation to erect that monument of national gratitude, Blenheim House. Both the architect, and this, his greatest work, were alternately censured and neglected, till Sir Joshua Reynolds vindicated his fame in his lectures to the Royal Academy. Next in order were Hawksmoor, the pupil of Wren, Lord Burlington, Kent, and Gibbs, of the latter of whom, Mr. Mitford observes, that allowing his talents to be small, how much do we owe to Lord Burlington, that by his precepts such a man was enabled to build one of the finest modern works, St. Martin's Church in the Fields. To Lord Burlington, indeed, it is probable we owe more than is generally considered, for besides the patronage he afforded to the artists of his time, and the assistance he gave them from his own genius, it is perhaps owing to his example, that a general feeling of attachment to the arts was conceived by the young men of rank and fortune in England. The Turkish government, which in its prosperity ruled with a rod of iron the once fertile plains of Greece, began now, in its decline, to relax a little of its ancient rigour, and these gentlemen were thus enabled to extend their travels (which before were bounded by the Archipelago) into this important country. Some of them formed at their return, the Dilettanti Society, for the encouragement of their researches into those (to modern times) new regions. These proceedings could not but excite great interest and curiosity in the public mind, which were fully gratified after some years by Mr. Stuart, who, in a long residence at Athens, made accurate drawings of most of the ancient buildings then existing. These were published in three volumes, folio, to which a fourth was afterwards added by Mr. Revely. The effects of these importations may be seen in every street in London.

The revival of the neglected architecture of the middle ages constitutes a new era in our history. Perhaps the first person who dared to recommend, by writing and example, a style so long in disrepute, was the celebrated Horace Walpole, Earl of Orford, who built the well-known villa of Strawberry Hill, to testify his fondness for it. This was succeeded by Lee Priory, by Mr. Wyatt, who quickly outstripped all the professors of his day, both in this style and the Roman. His greatest work in Gothic architecture was Fonthill Abbey: the purest taste reigned throughout the whole of this splendid structure, and the architect has thus bequeathed to succeeding professors a legacy of incalculable value.

We may now take the subject of architecture somewhat more in detail, and in accordance with our plan, proceed to examine the various "orders," as they are called, commencing with the Tuscan.

The Tuscan Order, as an antique, exists only in the works of Vitruvius, the description in which, being very obscure, has left a wide field for the ingenuity of modern architects. Among these Palladio composed two profiles; one from the description of the ancient master, and the other, according to his own idea of a simplification of the Doric. That of Vignola, however, has been most generally approved and adopted.

The base of this order consists of a simple torus,

with its fillet; it is, as are in general in all the Roman orders, accompanied by a plinth.

The proportions, from Sir W. Chambers, are as follow: the column, fourteen modules; the entablature, three modules, fifteen minutes. Of the former, the base occupies one module; the shaft (including the astragal, which divides it from the capital), twelve modules, and the capital one. Of the latter, the architrave (including the fillet), thirty-one minutes and a half; the frieze, the same; and the cornice, forty-two minutes.

The intercolumniations, in all the orders except the Doric, are the same; viz. the eustyle, which is most common and beautiful, four modules, twenty minutes; the diastyle, six modules; and the aræostyle, seven modules.

The Tuscan order admits of no ornaments, nor flutes in the columns; but rustic cinctures are sometimes represented on the shaft, an example of which occurs in the accompanying illustration, *fig.* 1.

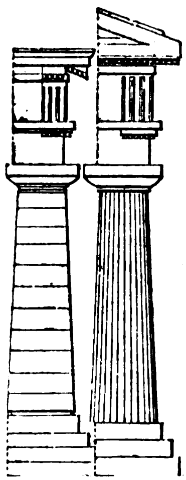


Fig. 1. *Fig.* 2.

This order may be employed in most cases, where strength and simplicity are required, rather than magnificence; such as prisons, market-places, arsenals, and the inferior parts of large buildings.

The Doric Order. We now come to an order, of which numerous ancient examples exist, and which will, in consequence, furnish us with more materials for description than the preceding. It is represented at *fig.* 2. The origin of the *Doric Order* is thus described by Vitruvius:

"Dorus, son of Hellen and the nymph Orises, reigned over Achaia and Peloponnesus. He built a temple of this order, on a spot sacred to Juno, at Argos, an ancient city. Many temples similar to it were afterwards raised in the other parts of Achaia, though at that time its proportions were not precisely established." This account, as well of those of the orders which we shall presently examine, is very incredible, and is now generally rejected.

From theory, however, we must now proceed to fact and description, and will commence with the Doric of the Greeks, referred to by Vitruvius (who nevertheless confounds this with what was commonly executed at Rome in his time). The most perfect example is the order of the Parthenon, or temple of Minerva, in the Acropolis at Athens, erected under the administration of Pericles, who lived about 450 years before the Christian era. We cannot do better than give the dimensions of this singularly fine specimen. The column (including the capital), ten modules, twenty-eight minutes and a half; the whole entablature, three modules, twenty-seven minutes and three-quarters; the capital, twenty-seven minutes and three-quarters; the architrave (with its fillet), one module, twelve minutes and three-quarters; the frieze, to the square member of the corona, one module, nineteen minutes; and the cornice, twenty-six minutes. Diameter of the column at the top, one module, sixteen minutes.

To proceed to the order designated by this title by the Romans. Very few ancient examples of this variation exist. The most perfect is that of the theatre of Marcellus, if, perhaps, we except that misshapen pile, Trajan's column, which is generally pronounced to be Tuscan. It is, therefore, principally indebted for its existence to the modern Italian architects, who, having little of antiquity before their eyes, appear to have bestowed more attention upon this order than the others, and it must be confessed that they have made of it a very elegant design, though, as before observed, essentially different from the original and true Doric. The measures, from Sir William Chambers, are as follow: the base, thirty minutes; the shaft, thirteen modules, twenty-eight minutes; and the capital, thirty-two minutes; the architrave, thirty minutes; the frieze to capital of triglyph, forty-five minutes; and cornice, forty-five minutes. Upper diameter of column, fifty minutes.

In no example of antiquity is the Doric column provided with a base. This circumstance has occasioned no small perplexity to some of those fanciful writers, who seek in every point some analogy to the human figure, or the trunk of a tree. Vitruvius, indeed, has told them that the base is a *shoe*, first invented to cover the nakedness of the matronly prototype of the Ionic order. "But," says Monsieur Le Clerc, "I must own I cannot consider a column without a base, comparing it to a man, but I am, at the same time struck with the idea of a person without feet, rather than without shoes; for which reason I am inclined to believe, either that the architects had not yet thought of employing bases to their columns, or that they omitted them in order to leave the pavement clear, the angles and projection of bases being stumbling-blocks to passengers, and so much the more troublesome, as the architets of those times frequently placed their columns very near each other, so that, had they been made with bases, the passages between them would have been extremely narrow and inconvenient." Accordingly, to supply this defect, as it was considered in this order, most architects have employed the *attic base*, which is common to all the orders except the Tuscan, though belonging, perhaps, more peculiarly to the Ionic.

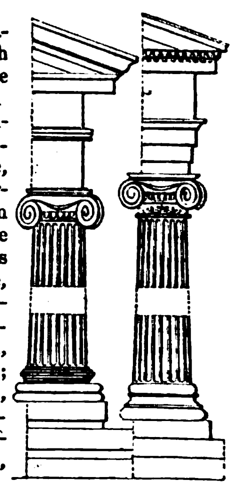
It consists of two tori, with a scotia and fillets, between the upper of which, in this version, resembles an inverted ovolo. The fillet above the upper torus is always connected with the shaft by a curve, as is also that under the capital, for which reason they are commonly considered as part of the shaft. The *plinth*, or square member beneath, is usually understood, in Roman architecture, as an indispensable appendage to the base, though Palladio has omitted it in his Corinthian order; but it is rarely found in the Greek specimens. To save this order, however, from the sad humiliation of being obliged to borrow a shoe when required to wear one, Vignola provided it with this appendage. His base consists of one large torus, with one considerably smaller resting upon it, surmounted by the fillet.

M. Le Clerc has, however, we apprehend, discovered the true reason why, at least in the latter Greek specimens, the base is omitted; namely, the very narrow intercolumniations. In the Greek order alteration is not probable, and perhaps not desirable; but in the Roman, where this addition has been long provided for us, and the intercolumniations adjusted accordingly, the omission would be certainly improper.

The most striking peculiarity in this order is the *triglyph* (supposed by Vitruvius to be the end of the joists laid transversely on the beam of the architrave), which forms the technical distinction between the Grecian and Roman Doric, being in the former always placed at the corner of the entablature, and in the latter, invariably over the centre of the column. This circumstance is a corroboration of the objection against the notion of the timber prototype; for, following the idea of the Egyptian origin of Greek architecture, there is found in the large hollowed crown moulding of the temple of Tentyris, a decoration very similar to the Doric triglyph, the extreme parts of which are placed at the angle, like the Greek Doric, but which, from their situation, bear not the least resemblance to the ends of pieces of wood. The triglyph is surmounted by the mutule, in the Greek, and in some Roman examples inclined, but in most modern profiles horizontal: on its soffit are represented guttæ, or drops. The spaces between the triglyphs on the frieze, are called metopes, which, in the modern Doric, are invariably perfectly square, and generally enriched with sculptures. Those which formerly adorned the metopes of the Parthenon were brought to this country by Lord Elgin, and now form the principal part of the collection which is known by his name at the British Museum. In the modern order these sculptures are most commonly an alternate bull's scull, and patera. The extreme projections of all these ornaments should be less than that of the trilgyph itself, thus keeping a due subordination between mere decorations and essential parts. All the Grecian Doric columns are fluted, and in both Greek and Roman this is performed without fillets between, as in the other orders. The intercolumniations in this order differ from those of the others, on account of the triglyph, the metopes being required to be exactly square. They are as follow: the coupled columns of course must stand under adjoining triglyphs; this make their distance, at the foot of the shaft, twenty-one minutes. The next intercolumniation is the monotriglyph, having *one* between the columns; the distance is three modules. The diastyle—two triglyphs, five modules and a half. The aræosistile, which has three between, eight modules.

The Ionic Order. The account of this order, which is given by Vitruvius, informs us, that in a general assembly of the Grecian states, thirteen colonies were sent over into Asia, by the Athenians; the expedition being led by Ion, whom the Delphic oracle which directed the emigration had acknowledged for the offspring of Apollo. They settled on the borders of Caria, and built several cities of great fame, of which were Ephesus, Miletus, Samos, and Colophon, to which Smyrna was afterwards added: and after the expulsion of the original inhabitants, these colonies were denominated Ionian, from the name of their chief. "In this country," continues he, "allotting different sites to sacred purposes, they erected temples, the first of which was dedicated to Apollo Panionius. It resembled that which they had seen in Achaia, and, from the species having been first used in the cities of Doria, they gave it the name of Doric. As they wished to erect this temple with columns, and were not acquainted with their proportions, nor the mode in which they should be adjusted, so as to be both adapted to the reception of the superincumbent weight, and to have a beautiful effect, they measured a man's height by the length of the foot, which they found to be a sixth part thereof, and thence deduced the proportion of their columns. Thus the Doric order borrowed its proportion, strength, and beauty from the human figure. On similar principles they afterwards built the temple of Diana, but in this, from a desire of varying the proportions, they used the female figure as a standard, making the height of the column eight times its thickness, for the purpose of giving it a more lofty effect. Under this new order they placed a base as a shoe to the foot. They also added volutes to the capital, resembling the graceful curls of the hair, hanging therefrom to the right and left certain mouldings and foliage. On the shaft, channels were sunk, bearing a resemblance to the folds of a matronal garment.* Thus were two orders invented, one of a masculine character, without ornament, the other approaching the delicacy, decorations, and proportion of a female. The successors of these people improving in taste, and preferring a more slender proportion, assigned seven diameters to the height of the Doric column, and eight and a half to the Ionic. The species, of which the Ionians were the inventors, received the appellation of Ionic."

The most beautiful Grecian specimens of this order are the temple on the Ilyssus, and the temples of Neptune Erectheus, and Minerva Polias, in the Acropolis at Athens, the two latter of which are so similar, that we shall not here discriminate between them. We are thus reduced to two Greek examples, and these are so exquisitely beautiful, that it is difficult to give the preference to either. We shall therefore describe both. The temple on the Ilyssus is the plainer of the two: its volute consists of a single spiral with a deep channel between, and is separated from the shaft by the sculptured echinus. The architrave is not broken into fasciæ, as in most other specimens. The cornice consists simply of a square member, with an echinus and fillet surmounted by the cymatium: the bed-mouldings in the elevation are completely concealed. The base is composed of two tori, the upper of which is channelled horizontally, and surmounted by a bead, inclosing a very flat scotia, the upper fillet of which projects as far as the extremity of the torus. The flutes are semi-elliptic.



The following are the measures of this order, of which specimens are shown in the engraving. The column, including base and capital, sixteen modules, fourteen minutes and one-fifth; the base, twenty-nine minutes and four-fifths; the capital (to bottom of volute), forty minutes. The architrave, fifty-five minutes and two-fifths; the frieze, forty-nine minutes; the cornice, thirty minutes and one-fifth. Width of the capital, three modules, three minutes; upper diameter of column, fifty-one minutes. Intercolumniation from centre to centre of column six modules, five minutes and two-fifths.

* All the Grecian Doric columns have flutes; a fact Vitruvius does not appear to have been aware of.

The specimens furnished in the temple of Minerva Polias are next to be considered. This example is much richer, yet no less elegant than the other: the volute, instead of a single spiral, is formed by three: the sculptured echinus beneath is surmounted by a guilloched moulding, and separated from the shaft by a neck adorned with honey-suckles. The base is very similar to that of the temple on the Ilyssus, except that its beauty is increased by the diminution of its height, the scotia is deeper, and the upper torus is guilloched. The architrave consists of three fasciæ, and the cornice is similar to that of the Ilyssus temple, except that the echinus and bed-moulding are sculptured, and the astragal of the latter is seen in the elevation beneath the corona.*

The column, including base and capital, is eighteen modules, seven minutes and one-tenth in height; the base, twenty-four minutes; and capital, forty-two. The architrave, forty-five minutes and one-fourth; the frieze, forty-seven minutes and four-fifths; and cornice (to the fillet of the echinus, which is the greatest *actual* height of the entablature, the cymatum being a restoration), twenty minutes and two-fifths. The width of the capital, three modules, three minutes. Upper diameter of column, forty-nine minutes and a half. Intercolumniation (from centre to centre), nine modules. Both these orders are destitute of insulated plinths.

Having thus given our readers an idea of the finest Greek specimens of this order, we must now proceed to the Roman and Italian version of it. It is the peculiarity of this order, that its front and side faces are dissimilar. To obviate this inconvenience, the Greeks twisted the extreme volutes of a portico so as to make the two faces alike. But Scamozzi, a famous Italian architect, designed a capital in which the volutes proceeded angularly from the shaft, thus presenting the same front every way; and the capital so executed has been generally attributed to the supposed inventor. Sir William Chambers, however, is of opinion that Michael Angelo was the author of one of this description in the Vatican at Rome.† This capital is commonly known as the modern Ionic, but has not been often executed in large works. The frieze of this order has been, by many architects, and Palladio among the number, pulvinated, or rounded in its contour, and smaller than the architrave, as though it were pressed down and bent by the superincumbent weight; but the ill effect of this has been so generally perceived, that it is rarely to be seen in late works. The cornice is distinguished from the Greek by its variety of mouldings, among which the most remarkable is a square member in the bead-mouldings, cut into small divisions, somewhat resembling teeth, whence they are called *dentils*. In other points of variation between the Grecian and Roman architecture there may be a difference of opinion; but with respect to the Ionic capital, we conceive this to be impossible. Whoever compares the meagre, petty form of the capital of the temple of Concord, with that of the Erectheion, must instantly, whatever be his former prejudices, perceive the amazing difference, and unhesitatingly acknowledge the vast superiority of the latter. The poverty of the solitary revolving fillet, the flat, insipid lines, and the enormous projection of the clumsy echinus, combine to render this the very worst feature in all the Italian orders. The base commonly used is the Attic, though Vitruvius has appropriated one to this order, resembling the Corinthian without its lower torus.

The following are the measures of the order from Sir William Chambers: The base, one module; the shaft, sixteen modules nine minutes; and capital, twenty-one minutes. The architrave, forty minutes and a half; the frieze, the same; and cornice, fifty-four minutes. Width of capital, two modules, twenty-six minutes. Upper diameter of column, fifty minutes.

"As the Doric order," says Sir William Chambers, "is particularly affected in churches or temples dedicated to male saints, so the Ionic is principally used in such as are consecrated to females of the matronal state. It is likewise employed in courts of justice, in libraries, colleges, seminaries, and other structures having relation to arts or letters; in private houses, and in palaces; to adorn the women's apartments, and, says Le Clerc, in all places dedicated to peace and tranquillity. The ancients employed it in temples sacred to Juno, to Bacchus, to Diana, and other deities whose characters held a medium between the severe and the effeminate."

The Corinthian Order.—The story of the origin of this order, given by Vitruvius, is as follows: "The third species of columns, which is called Corinthian, resembles in its character the graceful, elegant appearance of a virgin, whose limbs are of a more delicate form, and whose ornaments should be unobtrusive. The invention of the capital of this order arose from the following circumstance. A Corinthian virgin, who was of marriageable age, fell a victim to a violent disorder: after her interment, her nurse collecting in a basket those articles to which she had shown a partiality when alive, carried them to her tomb, and placed a tile on the basket for the longer preservation of its contents. The basket was accidentally placed on the root of an acanthus plant, which, pressed by the weight, shot forth towards spring in stems of large foliage, and in the course of its growth reached the angles of the tile, and thus formed volutes at the extremities. Callimachus, who for his great ingenuity and taste in sculpture was called by the Athenians κατατεχνος, happening to pass by the tomb, observed the basket, and the delicacy of the foliage which surrounded it. Pleased with the form and novelty of the combination, he took the hint for inventing these columns, and used them in the country about Corinth, regulating by this model the manner and proportion of the Corinthian order. A beautiful illustration of this story will be found under Acanthus.

It has been before observed in our notice of Egyptian architecture, that the capitals to be found in that country are much more likely to have given the hint for the Corinthian than the circumstance here mentioned. The only pure example of this order in Greece is the monument of Lysicrates, of which a view is given in a subsequent page. The capital of this specimen is exquisitely beautiful, but the same praise cannot be awarded to the entablature: the architrave is too large, and the frieze extremely small; the bead-mouldings of the cornice (which completely overpower the corona) consist of large dentils, supported by the echinus, and surmounted by a cyma

* This is most beautifully executed at St. Pancras church, at the east end; in the interior the capital and base are carved in marble, with the shaft of scagliola work resembling verde antique. In the portico of this church that of the Erectheion is copied.

† It may be seen in the beautiful circular portico of All Souls' church, built by Mr. Nash in Langham Place.

recta under a cyma reversa, which supports the corona. The base is extremely beautiful, resembling that of the temple of Minerva Polias, except that an inverted echinus is substituted for the upper torus: the base stands upon a large inverted cavetto, connected with the continued plinth by another inverted echinus. The flutes terminate upwards in the form of leaves, instead of being divided from the capital as usual by an astragal. The building is circular, and its centre is the summit of an equilateral triangle, of which the base is a line bounded by the centres of any two of the columns: the intercolumniation is six modules, thirteen minutes and one-fifth. Height of the column, twenty modules, thirteen minutes and two-fifths, of which the base occupies twenty-one minutes; and the capital, two modules, twenty-seven minutes. The architrave, fifty-three minutes and two-fifths; the frieze, forty-one minutes and two-fifths; and the cornice forty-eight minutes and four-fifths. The finest Roman example of this order is that of three columns in the Campo Vaccino at Rome, which are commonly considered as the remains of the temple of Jupiter Stator. This example has received the commendation of all modern artists, yet has seldom been executed in its original form. This is probably owing to the excessive richness and delicacy of it, which renders its adoption very expensive, and perhaps the modification of it by Vignola is preferable to the original, possessing a sufficient enrichment without the excessive refinement of the other. In this order (which has been adopted by Sir William Chambers) the base is one module in height; the shaft, sixteen modules, twenty minutes; and the capital, two modules ten minutes; thus giving ten diameters to the whole column. The architrave and frieze are each one module, fifteen minutes in height, and the cornice, two modules. The cornice is distinguished by modillions interposing between the bead-mouldings and corona; the latter is formed by a square member surmounted by a cymatum supported by a small ogee: the former is composed by dentils, supported by a cyma reversa, and covered by the ovolo. When the order is enriched, which is usually the case, these mouldings, excepting the cymatium and square of the corona, are all sculptured: the column is also fluted, and the channels are sometimes filled to about a third of their height with cablings, which are cylindrical pieces let into the channels. When the column is large, and near the eye, these are recommended as strengthening them, and rendering the fillets less liable to fracture; but when they are not approached, it is better to leave the flutes plain. They are sometimes sculptured, but this should be only in highly enriched orders. An example is given in *fig.* 1.

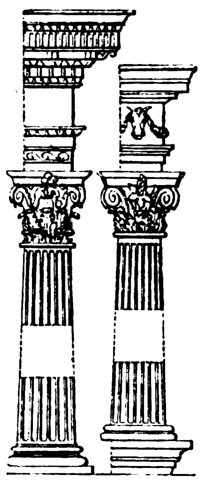


Fig. 1. *Fig.* 2.

The flutes are twenty-four in number, and commonly semicircular in their plan. The Corinthian base is similar to that of the composite order, excepting that two astragals are employed between the scotiæ instead of one; but the Attic is usually employed for the reasons before assigned.

"The Corinthian order," says Sir William Chambers, "is proper for all buildings where elegance, gaiety, and magnificence are required. The ancients employed it in temples dedicated to Venus, to Flora, Proserpine, and the nymphs of fountains, because the flowers, foliage, and volutes with which it is adorned seemed well adapted to the delicacy and elegance of such deities. Being the most splendid of all the orders, it is extremely proper for the decoration of palaces, public squares, or galleries and arcades surrounding them; for churches dedicated to the Virgin Mary, or to other virgin saints, and on account of its rich, gay, and graceful appearance, it may with propriety be used in theatres, in ball or banquetting rooms, and in all places consecrated to festive mirth, or convivial recreation."

The Roman, or *Composite Order*.—This order (though not considered by them as a distinct one) was employed by the Romans principally in triumphal arches, the column and entablature being the same as, or little differing from, the Corinthian.

The difference was, however, sufficient for the Italians to ground a new order upon. The capital, as being *composed* of the Ionic and Corinthian, they termed *composite*, and to justify the application of the name to the order in general, they combined in the entablature the dentils of the Ionic with the mutules of the Doric, and enrichments of the Corinthian, and gave to the architrave but two fasciæ, thus rendering it in some respects more simple, but more enriched than the latter, while the former had little but the name left in the composition. The whole order may be safely pronounced to be heavy, without possessing grandeur, and rich, though destitute of beauty. It has not been frequently adopted, and it is to be lamented that Sir Christopher Wren has made so much use of it about St. Paul's.

The base commonly appropriated to this order is extremely beautiful: it consists of two tori (the lower of which is considerably the larger), with two scotiæ enclosing an astragal. This is called the *proper* base of the order, but the Attic is usually employed, being more simple, and consequently less expensive than the other.

The measures of this order, from Sir William Chambers, are as follow: the base, thirty minutes; the shaft, sixteen modules, twenty minutes; and capital, two modules, ten minutes. The architrave, forty-five minutes; the frieze, forty-five minutes; and the cornice, two modules. A column of this order is shown at *fig.* 2.

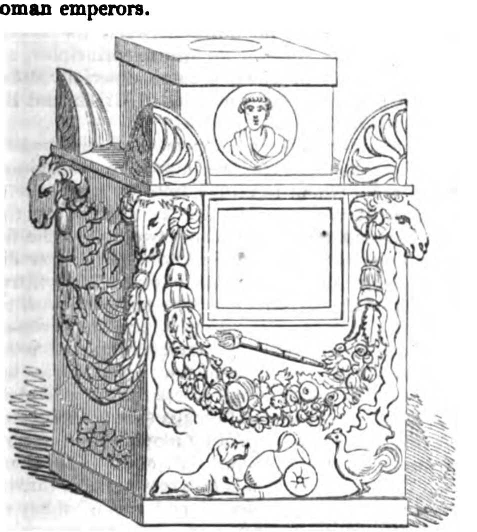
Persians and Caryatides.—Having now described what are called the regular orders, it is necessary to notice in the next place the employment of human figures instead of columns for the support of an entablature. We will first give, as in former cases, the account of Vitruvius. "Carya, a city of Peloponnesus, took part with the Persians against the Grecian states. When the country was freed from its invaders, the Greeks turned their arms against the Caryans, and upon the capture of the city put the males to the sword, and led the women into captivity. The architects of that time, for the purpose of perpetuating the ignominy of this people, instead of columns in the porticos of their buildings, substituted statues of these women, faithfully copying their ornaments, and the drapery with which they were

attired, the mode of which they were not permitted to change."

There are two great objections to the truth of this story: first, that the circumstance is not mentioned by any of the Grecian historians; and secondly, that it is certain animal figures were employed for this purpose long previous to the time assigned by Vitruvius.

Having thus shown our readers what is *not* the origin of these figures, it must next be our business to inform them what *is*, or rather what is most probable, and for this purpose we must trespass on the kindness of Mr. Gwilt, the only writer we believe who has given a satisfactory account of them. He conjectures the name to have arisen from the employment of them in temples to Diana, who is supposed to have made the Lacedæmonians acquainted with the story of Carya (turned into a nut-tree by Bacchus, who also transformed her sisters into stones), and thence worshipped by them under the name of *Caryatis*. Thus, being first employed in temples dedicated to this goddess, they afterwards came into use in other buildings as representations of the nymphs who assisted at the mysteries of the patron goddess. They may be seen at St. Pancras Church, correctly copied from the Pandroseum. An example is given in the accompanying wood-cut of an older date, though the figure is much more beautifully formed.

The ancient cenotaph or tomb furnished some of the most beautiful displays of architectural ornament, executed either by the Greek or Roman sculptors. We furnish one erected to the memory of one of the Roman emperors.



The ornaments were all of a funeral character, and there is reason to suppose that the above cenotaph differed from many of a nearly similar character, inasmuch as it was intended to hold the remains, instead of being merely an honorary memento.

The ornaments, it will be seen, consist of heads supporting wreaths of flowers. Speaking of this species of ornament, Mr. Kempe observes in a late volume of the *Archæologia*, "garlands were so much used by the ancients at their sacrificial and social feasts, that as the patines for libation, and the sculls of victims, from being at first suspended on the friezes of their temples, became at last sculptured on them in stone, so were the vegetable wreaths at length transferred in a similar manner." We quote Mr. Kempe, as he is a good antiquary and a learned scholar; and there is but little doubt but that the greater part of the architectural ornaments of this character had their origin on altars and monuments, and were from thence transferred to the portico, frieze, and column of the temple.

We may now furnish an exemplification of the use of the column in one of the most beautiful monuments of Grecian architecture extant. We allude to the choragic monument of Lysicrates, a portion of which is shown in the accompanying engraving.

This edifice, which is usually, but erroneously, termed the "Lantern of Demosthenes," stands near the eastern end of the Acropolis. It consists of a circular colonnade supporting a *tholus* or cupola, with the highly enriched foliage ornament represented in the figure. Illustrations of complete edifices in the various styles we have described in the course of this article, will be found in another portion of our work, and we now at once proceed to that which has not unaptly been called the English Style or order.

It has been before observed, that the rude buildings of the Saxons and Normans in this country, which are evidently copied from those of the Romans, may, by gradual improvement, have given rise to Gothic architecture; and that this was the case in England at least there is no doubt. But there are certain peculiarities even in these crude and imperfect attempts (though afterwards more fully developed) which require to be noticed before we proceed further, plainly indicating that the works in question were raised under the influence of a less ardent sun, and more obscured sky. In the happy climate of Greece, where little was to be feared from change of

weather, the temples (the only buildings much distinguished for architectural excellence) were frequently destitute of covering. Windows, in this case, being entirely superfluous, the walls were, in many instances, pierced only by a single door, which served at once for ingress and egress both to priests and worshippers. Science here, therefore, was not needed, and indeed is not to be found. With the practical application of the principle of the arch the Greeks do not appear to have been acquainted; the large stones, which in those early ages were to be procured in abundance, being sufficient to cover the columns and the opening of the doors. As architecture improved, however, roofs were added to these edifices, and to throw off the rain they were inclined downwards from the centre to the extremities. This inclination, in a climate where so little rain or snow fell, required to be but small; but in Rome, which is more northern, it was found convenient to increase it to meet the exigencies of the situation. In countries far more exposed to vicissitudes of weather than either of these, it is evident that a very different pitch will be requisite, and this theory is verified by the buildings of northern climates, the architects of which, though totally unacquainted with the works of their southern predecessors, by a singular coincidence adapted their roofs to their latitude in a regular scale of gradation from them. The Saxon and Norman architects, though they did not comprehend this principle in the perfection to which it was afterwards carried, were sensible of the wants of the climate, and made their roofs much higher than those of their Roman prototypes.

This circumstance presenting itself to minds so quick to perceive, and so able to adopt, any novelty which came recommended by utility and beauty as those of the architects of the middle ages, could not fail of meeting with the highest attention. It was soon seen that unbroken vertical lines and lofty buildings were necessary to harmonize with the high pitched roof, and the pointed arch is but a natural and easy deduction from these *data*.

But there is another and an important peculiarity in buildings designed for northern climates to which we must next call the reader's attention. This arises from the numerous circumstances which in these regions conspire to obscure the rays of the sun. The great darkness which prevails in them, compared with the countries of Greece and Italy, evidently requires a very different arrangement in the public buildings, and this circumstance has received no small share of the attention of the architects whose works we are considering. The variety and beauty of its windows is not the least striking peculiarity of Gothic architecture, and indeed they form the readiest criterion for distinguishing the several styles, as we have already seen in the *art.* Arch.

A third essential point of distinction between this style and all others, consists in the different *purposes* for which the edifices in which it is most apparent were constructed, and the different *ceremonies* for which they were adapted. Although the rites of Greek and Roman paganism were numerous and splendid, they required little aid from architecture: the ceremonies with which they were connected were principally performed in the open air, and the temple was only used as a receptacle for the statue of the deity, before which sacrifices were offered, and prayers preferred.

But Christian worship under papal guidance, and in a country where the atmosphere was so cold as to render shelter requisite for the performance of its ceremonies, required other arrangements in the edifices dedicated to it: for its numerous and splendid processions, was provided a long, narrow, and lofty gallery, called *the nave;* for the reception of the multitude to witness these, adjacent wings were added, called *aisles.* A *choir* was added for the actual performance of the sacred rites, and numerous *chapels* to commemorate the bounty of individuals were dispersed about the edifice.

All these essential appendages necessarily occupied a space of great magnitude, and the figure of the *cross,* held by the Romish Church in the most profound veneration, was pitched upon to regulate the general form of the building thus constituted. Our reason for mentioning these particulars is, to show the absolute necessity which thus arose for a degree of science and mathematical knowledge, not dreamt of by the architects whose works are received as the sole standards of excellence by most of the professors of modern times. The narrow intercolumniations of the Grecian buildings would have been ill adapted for the display of feudal magnificence, and the stones within the reach of the builders were far too small to have covered even these. Thus the arch became unavoidably a prominent feature in the style. To give greater magnificence to the nave it was made a story higher than the aisles. The wall of this upper story is supported by a tier of arches supported by large piers, which divides the nave from the aisles. The upper, or *clere* story, as it is called, has windows answering to those beneath. To form an interior roofing which should at once hide the timbers above and furnish an appropriate finish to the architecture, the same contrivance was resorted to, and from this cause have proceeded those vast monuments of daring ingenuity which, while they excited the admiration, have baffled the rival attempts of modern architects.

Having thus traced, we hope, perspicuously and satisfactorily, the causes which gave rise to Gothic architecture, and led to its perfection; it will be proper, before discriminating between its several styles, to explain some of its leading principles, and those particulars in which it more especially differs from the better known principles of Greek and Roman architecture.

Of these, the first in importance is the pointed arch, of which there are three kinds. 1. The simple pointed arch, which is struck from two centres on the line of the impost. 2. The Tudor arch, or that which has four centres, of which two are on the line of the impost, and the other two at any other distance. 3. The ogee, which has likewise four centres, two on the impost line, and two on a line with the apex, the segments struck from which are reversed. This form is used only in tracery, or small work, except as a canopy or dripstone over doors and windows. The pointed arch differs from the semicircular, as employed by the Romans (besides its form), in having its soffit occupied by mouldings of various projections, instead of being flat, enriched with panels. The cause of this is its great breadth (having frequently to support a wall and roof), which required the piers to be of corresponding magnitude, to diminish the unpleasing effect of which, the architects surrounded them with slender shafts. The

projections of these being carried into the arch, caused it to be of the form in question. It is scarcely necessary to add, that these piers are always undiminished. Arising from the general use of the arch is that of the buttress. In Norman work this was avoided by the employment of walls of vast thickness, with very small windows; but when architecture began to assume a lighter character, the windows were enlarged, and the thickness of the walls diminished. To compensate for this deficiency, the buttress was employed, at once to resist the pressure of the arches within, and to prevent the necessity of the walls being of an unwieldy thickness. These are often divided into stages (each being of less projection than that beneath it) finished by pinnacles, and from the upper part of them spring insulated arches, serving as a protection for the clere story.

The next thing to be mentioned is the *steeple*, with its component parts and accompaniments. When square topped, it is called a tower, which is often crowned with a spire. Slender and lofty towers are called *turrets*, and are commonly attached either to the angles of a large tower (when they frequently contain staircases), or to the angles of a building. They are sometimes surmounted by spires, a beautiful example of which may be seen at Peterborough Cathedral, in the turret at the north-west angle. In this exquisite and unique design the turret is square, and decorated at the angle with boltels, which are carried up beyond it, and finished by a triangular pinnacle. The spire in the centre is octagonal, and rectangularly placed within the square, four of its sides thus forming triangles with the angular boltels, which being arched over, form grounds for pinnacles of the same form, which are carried up to about half the height of the spire itself. The effect is beautiful beyond description, and merits the most attentive examination.

Next in importance are the *windows* of Gothic architecture, but as these differ so widely in the several styles as to form the readiest criterion for distinguishing them, they will be more properly noticed when we speak of these styles. We shall pursue the same plan with the doors, and other subordinate parts.

It may be proper in this place to say something of the *mouldings* of Gothic architecture. Of these, that which bears the most resemblance to the Roman mouldings is the *ogee*, distinguished by the same name, or that of cyma reversa, in the nomenclature of the Italian school. A moulding used for the same purpose as the cyma recta, and much resembling it, is also found, more frequently perhaps than any other. That which is most peculiar to the style, is the *boltel*, or cylindrical and nearly detached moulding, often answered by a corresponding hollow, which forms one of the happiest species of relief which could have been resorted to.

We shall now detail the different styles of Gothic architecture, with the peculiarities of each, and in so doing, follow the arrangement and nomenclature of Mr. Rickman, the only writer who has attempted to give a clear and practical account of this beautiful though neglected style. He distinguishes three variations, which may, without impropriety, be called the *orders* of Gothic architecture; differing, however, from the Greek and Roman orders in this circumstance; that while they are confined to one part of a building, or at most, affect the rest only in regard to strength or delicacy, these extend through every part of the edifice.

The first style, denominated by Mr. Rickman "Early English," commenced with the reign of Richard the First, in 1189, and was superseded by the next in 1307, the end of the reign of Edward the First. It is principally distinguished by long narrow windows, and bold ornaments and mouldings. The window being so essential a mark of the style, claims to be considered in the first place.

The Early English window is invariably long and narrow; its head is generally the lancet, or highly pointed arch, but is sometimes formed by a trefoil. In large buildings there are generally found two or more of these combined, with their dripstones united. Three is the usual number, but sometimes four, five, seven, and in one instance (the east end of Lincoln Cathedral) eight are employed. When combined, there is usually a quatrefoil between the heads, and where there are many, the whole is sometimes covered by a segmental pointed dripstone, to which form the windows are adapted, by the centre one being raised higher than the rest, which are gradually lowered on each side to the extremity. Sometimes, in late buildings, two windows have a pierced quatrefoil between them, and are covered by a simple pointed arch as a dripstone, thus approaching so nearly the next style as not to be easily distinguished from it: this arrangement may be seen in the nave of Westminster Abbey. In large buildings the windows are frequently decorated with slender shafts, which are usually insulated and connected by bands with the wall. A fine example of this may be seen at the Temple Church, London, one of the purest buildings existing of this style.

The circular, rose, or catherine-wheel window is frequently found in large buildings of this style, in which, however, it did not originate, being found in Norman edifices. It appears to have received much attention from the architects of the period, being worked with great care.

The doors of this style are distinguished by their deep recess; columns usually insulated in a deep hollow, and a simple pointed arch, nearly equilateral in the interior mouldings, but in the exterior, from the depth of the door, approaching the semicircle. They are also frequently ornamented by a kind of four-leaved flower placed in a hollow. In large buildings they are often divided by one or more shafts (clustered) in the centre, with one of the circular ornaments above.

To the steeples of this period were added, in many instances, spires, many of which are finely proportioned and form a very characteristic and elegant finish to the buildings they accompany. They have usually ribs at the angles, which are sometimes crocketed; and in some instances they are still farther enriched with bands of quatrefoils round the spire. The towers are usually guarded at the angles by buttresses, but octagonal turrets are sometimes met with, surmounted by pinnacles of the same plan. In small churches the slope of the spire sometimes projects over the wall of the tower, which is finished by a cornice, and the diagonal sides of the spire (generally octagonal) are sloped down to the angles.

The arches of this style are chiefly distinguished by very numerous, though, for their size, bold mouldings, with hollows of corresponding depth: the lancet arch is chiefly used, though many are found much more

obtuse. The form of the arch, indeed, as Mr. Rickman observes, is by no means a certain criterion for the distinction of the styles, each form being met with in buildings of each style, except the four-centered.

The piers are distinguished from those of the other styles by being surrounded with bands, which sometimes are confined to the shafts, and sometimes are continued on the pier. The capitals are usually composed by plain bold mouldings. The plan of these piers is usually a circle, surrounded by small shafts, but a beautiful variation is found in Salisbury Cathedral.

The buttresses of this style are chiefly distinguished by their simplicity, having very few sets-off, and very rarely any ornament in their faces. Frequently, indeed, as at Wells Cathedral (the nave of which is very early in this style), they retain the Norman form, of very broad faces with slight projections, with a shaft inserted in the angles, and are continued no higher than the cornice. The flying buttress was not used till late in this species of architecture.

The ornamental parts of the style now remain to be considered, which, till near its conclusion, were but sparingly used, and those, for the most part, of a very rude description. In the west front of Wells and Peterborough Cathedrals may be seen specimens of the taste of the period in these particulars, which are wholly unworthy of imitation; but in the interior of Salisbury are many details of a later date, which are very elegant, and will bear the most minute examination.

It may be sufficient to mention, that in all the ornamental and minute details during this period, as well as in the more important parts, the boldness and contempt of refinement, which are infallible marks of an early age, are very apparent, for which reason we shall defer the description of many ornamental details (which, nevertheless, were practised, and with success, in the latter part of this period) till the next style, in which they were brought to perfection.

There is, however, one ornament peculiar to this style which it is necessary to notice before we proceed farther. It resembles a low pyramid, of which the sides are pierced in the form of curvilinear triangles, bending inwards, and is usually placed upon a hollow moulding, from which it is sometimes entirely detached except the angles. It has yet received no regular appellation, on account of its being so unlike any other object as to be with difficulty described, or even delineated, and we believe it must be seen to be accurately comprehended. The only attempt at designation it has received is, the *toothed ornament*. The reason for applying such a name to it we leave for the ingenuity of the reader to discover.

The Early English style of Gothic architecture may, we think, without impropriety, be compared to the Doric order of the Greeks. Like that, it is the first attempt of a people emerging from barbarism, and like that, it possesses all those qualities which it is natural to expect from such a state of society. Strength and simplicity are its predominating characteristics: ornament, except the most bold and artless, is foreign to its nature, and can never be introduced with propriety. For this reason it may be employed with great advantage in churches, where expense is an object, as a finer effect may be produced by the use of this style than of any other whatever, at an equal cost. Of the fitness of Gothic architecture for ecclesiastical edifices, we presume it is now needless to say much. The circumstances of its having had its origin in Christian worship, and consequent adaptation to its ceremonies, its fitness for the climate, and its devotional effect upon people in general, seem to point it out as peculiarly appropriate for this service. In exterior effect Gothic architecture is very defective, and never more so than in this style. We have, indeed, scarcely one front which is at all reconcileable to good taste. That of Salisbury Cathedral is generally admired, but we can see no reason for the preference. A consciousness of this defect of the style led the architect of that of Peterborough Cathedral to make use of a singular expedient. Three ponderous arches supported by triangular piers receive the weight of three gables, and at each lateral extremity is a square turret, containing a staircase, and surmounted by a spire, one of which has been already described. The effect of the composition is grand, but it is not worthy of imitation. A field is thus offered for the exercise of modern invention, which, as this kind of architecture becomes better understood, it is to be hoped will not be neglected: much has been done, but something, we conceive, remains to do, to render it a worthy and formidable competitor with the long practised and deeply studied architecture of Greece and Rome.

The style next in order to the Early English is denominated, by Mr. Rickman, *Decorated English*, as possessing a greater degree of delicacy than the former, without the excessive detail of the style which succeeded it. It ceased to be used soon after the death of Edward the Third, which happened in 1307. Its prominent feature is also found in its windows, with which, therefore, we shall commence our description.

The windows of this style are distinguished from those of the last by being larger, and divided into lights by slender upright stones, called mullions.

Of decorated windows there are two descriptions. 1. Where the mullions branch out into geometrical figures, and are all of equal size and shape; and 2. Where they are dispersed through the head in curves of various descriptions (which is called flowing tracery) and are usually in windows of more than three lights, of different size and shape, the principal mullions forming simple figures, subdivided by the inferior ones. Sometimes the principal mullions are faced by slender shafts, with bases and capitals. The first description is considered the oldest; the principal example which contains these kind of windows is Exeter Cathedral, where they are very large, and nearly all composed of this kind of tracery. Plate 4, fig. 1. The architraves are commonly enriched by mouldings, which sometimes assume the form of columns, and the windows in composition frequently reach from pier to pier. The form of the arch is seldom more acute than that described on the equilateral triangle, and it is generally more obtuse. The richness of these windows invariably depends upon their size, the distance between the mullions being nearly the same in all: the largest, however, do not consist of more than nine lights. The dripstone is in this style improved into an elegant canopy, the form of which is sometimes pedimental, and sometimes an ogee arch: it is decorated with crockets and a finial, and the space inclosed by it and the exterior contour of the arch is sometimes filled with tracery. The great

ARTS. (FINE)

ROOF OF WESTMINSTER HALL

Fig. 3.

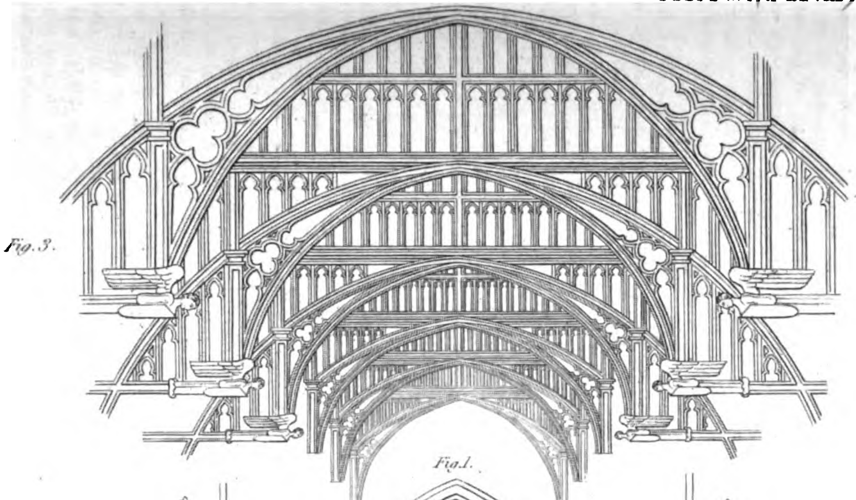
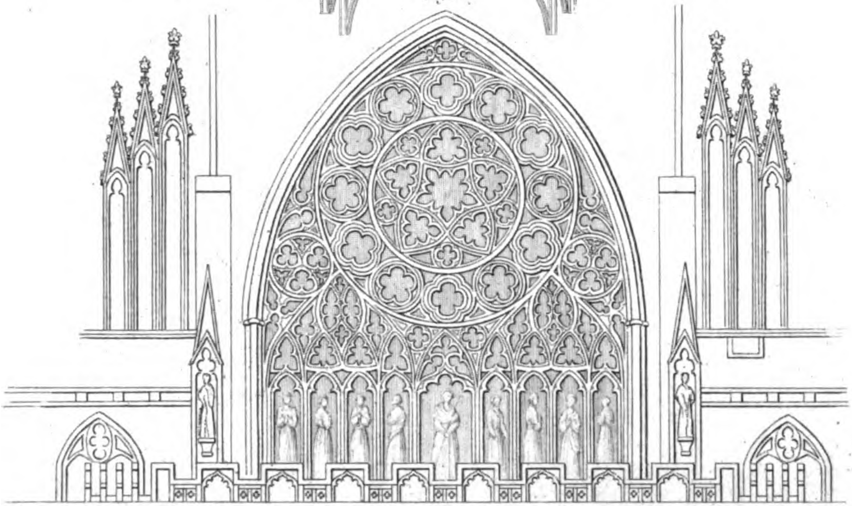
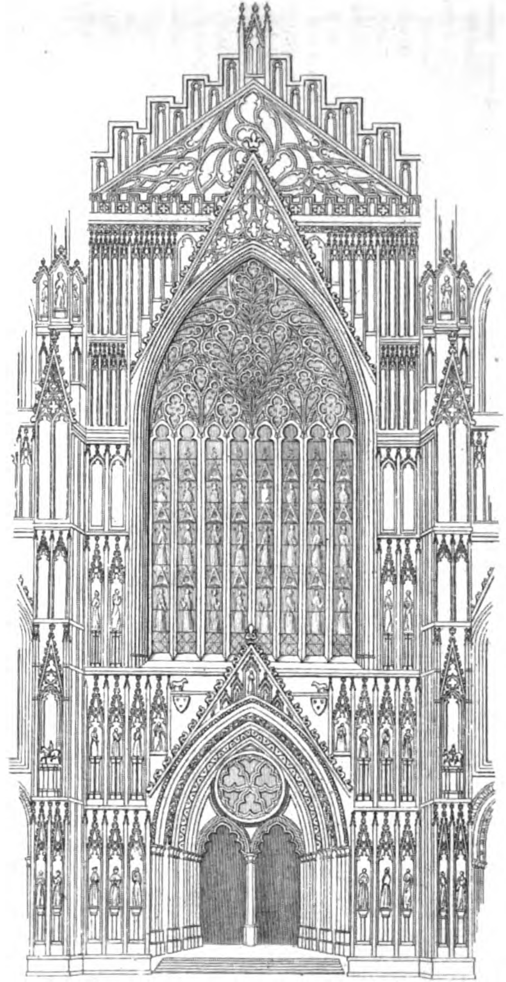


Fig. 1.



WEST WINDOW, EXETER CATHEDRAL

Fig. 2.



YORK CATHEDRAL

London Published by William Orr, Paternoster Row, Feb. 28, 1833.

west window of York Cathedral, one of the finest in the kingdom, has a triangular one. Plate 4, fig. 2.

The circular window was also brought to perfection in this style. A fine example in form, though not in detail, is now the only remains of the ancient palace of the Bishops of Winchester, in Bankside, Southwark. This is of the geometrical description; one of the finest of flowing tracery is in the south transept of Lincoln Cathedral.

The doors of this style are not so distinct as the windows, from those of the former period: double doors are not so frequent, and the shafts are not detached from the mouldings as in the Early English. In small doors there is frequently no column, but the mouldings of the arch are carried down the sides without interruption: there is frequently no base-moulding, but a plain sloped face to receive the architrave. They are surmounted by the same sort of canopies as the windows.

The steeples of this period are distinguished from those of the last in little more than their windows, and a few unimportant details. The north-west spire of Peterborough Cathedral, before described, decidedly belongs to it, though the tower beneath is Early English. The tower and spire of Newark Church, Lincolnshire, are pointed out by Mr. Rickman as a peculiarly fine example.

Of arches little can be said. Of their form, it may be sufficient to observe, that the lancet arch is rarely met with; the Tudor never but in one instance, the nave of Winchester Cathedral, built, or rather cased, by the celebrated William of Wyckham, and it is here necessarily adopted on account of the form of the Norman arch it was employed to conceal. The mouldings are in general less numerous, and consequently bolder than those of the preceding style. In small works the ogee arch is frequently found, and decorated with crockets, and a finial.

The piers of this style are, for the most part, square in their general form, and placed diagonally. The shafts are sometimes filletted, that is, a square narrow face is continued vertically along its surface, projecting slightly from it. The capitals are frequently enriched with foliage, and the bases, in many instances, consist of reversed ogees, with square faces of various projections, and sometimes other mouldings.

Decorated English buttresses are distinguished from those of the last style which are most applicable to it, only by their greater richness in buildings where decoration is not spared, and consequently, in others they are perhaps the least characteristic parts of the composition. They are, however, usually finished by pinnacles, which are generally distinguishable from those of the former style. The flying buttress is almost invariably used, and is also surmounted by a pinnacle, which usually corresponds with the lower one. The buttresses of the aisles of Exeter Cathedral are remarkable for being detached from the wall, the only support they afford to which, is by the arches which connect them with it at the top.

The parapets of this style are sometimes horizontal, and sometimes embattled, each of which are frequently pierced in the form of cinquefoil headed arches, quatrefoils, and triangles. Sunk panels are, however, more common. When plain embattled parapets are employed, the crowning moulding is usually continued horizontally only, the face towards the opening being merely a vertical section.

As many of the ornamental parts of Gothic architecture were brought to perfection during this period, they cannot be better introduced than in this place. Among these the use of crockets is a prominent feature: these are small bunches of foliage running up the side of the *gablet*, afterwards improved into the ogee canopy over doors, windows, and ornamental arches, and finished by a combination of two or more, called a *finial*, which is separated from the rest by a small moulding. They are also used to decorate the angles of pinnacles. Another peculiarity of Gothic architecture is the *feathering* of windows, screen-work, ornamental arches, panels, and sometimes doors. It is called trefoil, quatrefoil, or cinquefoil, according to the number of segments of circles (which are called *cusps*) of which it is composed. A very beautiful door thus ornamented, still exists in St. Stephen's Chapel, Westminster, now the House of Commons.

Although the grotesque is the prevailing character of the sculpture employed in the decoration of Gothic architecture, many small ornaments are found, particularly in this style, designed with taste and executed with the utmost delicacy. They are copied from the beautiful though humble flowers of the field, and are in many instances local.

We have compared the former style to the Doric of the Greeks, and the present may with little less propriety be likened to the Ionic of the same people. Boldness with simplicity characterize the first; elegance and delicacy the second. In both Greek and Gothic orders, ornament to profusion is allowable; yet in neither does it interfere with the composition, and may be entirely omitted. From this circumstance arises an universal applicability, belonging only to the far-famed "*happy medium,*" so often talked of, so seldom attained. In grandeur of composition, simplicity of arrangement, elegance of form, and *perfection* of capability, this style is therefore unrivalled, and may be used with advantage for every purpose of civil architecture. It is, however, perhaps, peculiarly adapted for all churches whose size and situation render them of importance; and in such large buildings where Gothic architecture may be thought desirable, as are of sufficient consequence to allow the architect to think of delicacy in the design of his details.

The last of the three grand divisions of Gothic architecture is the *Perpendicular* Style, commencing in the end of the second, and finally overwhelmed by its own superfluity of decoration and uncompromising minuteness. It was not wholly lost sight of before the reign of James the First, when few buildings were erected without a mixture of Italian work.

The Perpendicular Style, like the others, is most readily distinguished by its windows (whence it also derives its appellation); the mullions of which, instead of being finished in flowing lines, or geometrical figures, are carried perpendicularly into the head. They are further distinguished by a *transom* or cross mullion, to break the height, under which is usually a feathered arch, and sometimes it is ornamented above by small battlements. The architraves of windows in this style have seldom shafts or mouldings as in the former, but are worked plain, and frequently with a large hollow. Although these windows do not admit of any great variety in the disposition of the tracery, they are far more numerous than those of either of the other styles; few specimens of which remain, that do not bear marks of

the rage for alteration which appears to have prevailed at this period.

The *doors* of this style are remarkably varied from those of the preceding ones, by the arch being finished by a horizontal moulding, which is continued down to the springing of the arch, and then shortly returned. This is called a *label:* the space enclosed by it, and the exterior line of the arch is called the *spandrel*, which is commonly filled with a circle enclosing a quatrefoil or other circular ornament.

The *steeples* of this style are for the most part extremely rich: spires are seldom met with, but lanterns are frequently used. A lantern is a turret placed above a building, and pierced with windows so as to admit light into the space below. This is sometimes placed on the top of a tower, as at Boston, and supported with flying buttresses springing from it, and sometimes constitutes the tower itself, as at York, Peterborough, and Ely Cathedrals, where it is placed at the intersection of the cross, and has a very fine effect. The exterior angles are frequently concealed by octagonal turrets containing staircases, but usually strengthened by buttresses either double or diagonal. A most beautiful finish for a steeple is found in that of the church of Newcastle-upon-Tyne, where a small square tower (each side of which is nearly occupied by a window), surmounted by a spire, is wholly supported by arch buttresses springing from the pinnacles of the great tower.

Groining, in perpendicular work, assumes a new and more delicate character. A number of small ribs diverging from a centre, are carried up in the form of one side of a pointed arch, and terminated equidistantly from that centre by a semicircle. As they recede from the point, they are divided by smaller ribs or mullions, and those again subdivided (according to the size of the roof) so as to make all the panels of nearly equal size. These panels are ornamented with feathered arches, &c. in the same manner as the windows, in conformity to which the whole is designed. The intervals between these semicircles are filled with tracery of the same description. This kind of roof is called *fan tracery:* it is exquisitely beautiful, and almost the only kind of groining used in this style. Another description of roof must now be mentioned, of very different character; this is the timber roof, of which Westminster Hall presents so magnificent an example. Plate 4, fig. 3. Here the actual timbers of the roofs are so arranged as to form an architectural combination of great beauty: a wooden arch springs from each side of the building, supporting a pointed central one, finished downwards with pendants: the rest of the framing is filled with pierced panelling. This kind of roof is not found in churches, but it seems well adapted for large halls, appropriated to public business, or any place intended for the occasional reception of large meetings.

The *piers* are remarkable for their depth in proportion to their width: frequently there is a flat face of considerable breadth in the inside of the arch, and a shaft in front running up to support the groining. The capitals, when there are any, are generally composed with plain mouldings, but there is sometimes a four-leaved square flower placed in the hollow.

The *buttresses* and *pinnacles* contain little remarkable, and are only distinguished from those of the last style by their extraneous ornaments, if they have any: the buttresses are sometimes panelled, and in some very late specimens the pinnacles are in the form of domes, of which the contour is an ogee arch.

The *parapets* of this style are generally embattled and pierced; they are worked with great delicacy in the form of quatrefoil circles, &c.

Having in the preceding pages briefly detailed the various Styles, we may now furnish a few examples of their application in various edifices. The first of these is represented in Plate 2, Fig. 1, Fine Arts, forming the porch of Redcliffe Church, Bristol. The exact date of this part of the edifice is not known, but the external arch is very similar to one in the Church of Batalha, which was erected in the fourteenth century. It affords a very rare and beautiful example of the combination of the pointed arch with the morisco doorway.

The interior, fig 2, which forms our other example, is copied from King's College Chapel, Cambridge, and in point of elegant enrichment it has long been the admiration of all Europe. We have here at one view the whole system of clustered columns and groined roofing, which has served to render this style of architecture so peculiarly fitted for large and solemn edifices. The first stone of this edifice was laid in 1441.

Plate 3, fig. 1, represents the magnificent architecture of Egypt; fig. 2 of the same plate represents the front view and elevation of a Doric temple; fig. 3, that of an Ionic temple; and in fig. 4, the general effect of the Roman or Composite order is given, the other plates giving the details, are referred to in the body of the article.

ARCHITRAVE, in *Architecture*, the lower division of an entablature, or that part which rests immediately on the column. In all the ancient examples of the Doric order still existing in Greece, such as those at Athens and Corinth, and also those at Pæstum, and in Sicily, it has only one facia, and is of great height, being nearly equal to the diameter of the column. In the Doric order of the theatre of Marcellus at Rome, it has only one facia, but is much lower, being only equal to half a diameter of the column. The moderns, such as Vignola, Scamozzi, &c. have generally confined it to this proportion nearly, but have divided it into two facias, taking the idea from some ancient examples of the Doric order in Italy. This term is sometimes, though erroneously, applied to doors and windows.

ARCHIVAULT, the contour of an arch, or a frame set off with mouldings running upon the faces of the arch-stones, and bearing upon the imposts.

ARCTATIO, a constipation of the intestines from inflammation, or a preternatural straightness of the pudendum muliebre.

ARCTIC, in *Astronomy*, an epithet given to the north pole, or the pole raised above our horizon. It is called the arctic pole, from the constellation of the Little Bear, nearly pointing out the north pole.

The arctic circle is a lesser circle of the sphere, parallel to the equator, passing through the north pole of the ecliptic, and 23° 28′ distant from the north pole, from whence its name. This and its opposite, the antarctic, are called the two polar circles; and may be conceived to be described by the motion of the poles of the ecliptic, round the poles of the equator, or of the world. The arctic circle is the boundary of the north frigid zone.

ARCTOPHYLAX, in *Astronomy*, the Bear-Ward, a name for Boötes.

ARCTURUS, in *Astronomy*, a fixed star of the first magnitude, in the constellation of Arctophylax, or

ARTS. (FINE)

Fig. 1.

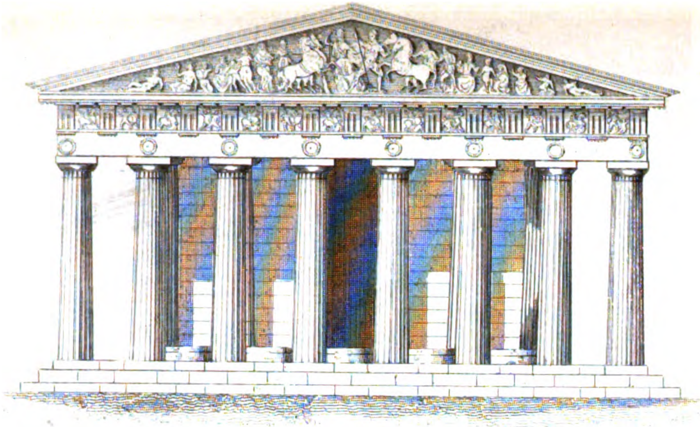
PORCH OF REDCLIFFE CHURCH.
BRISTOL.

Fig. 2.

KING'S COLLEGE CHAPEL.
CAMBRIDGE.

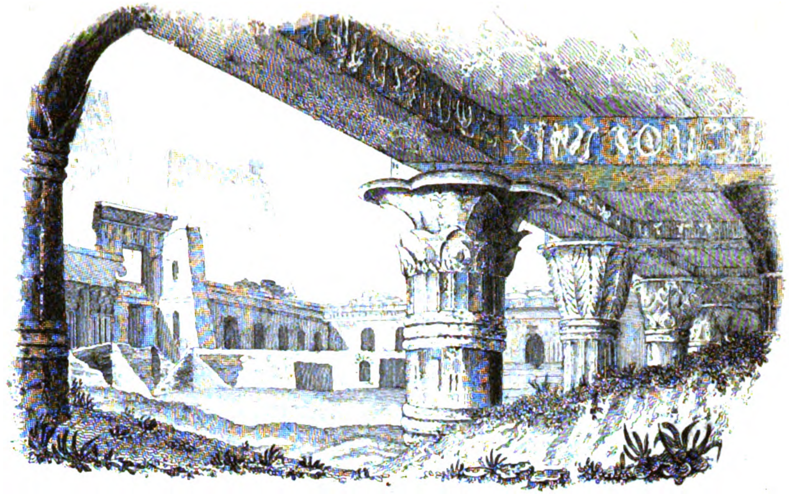
London. Published by William Orr, Paternoster Row. Jan. 29 1833.

Fig. 2.



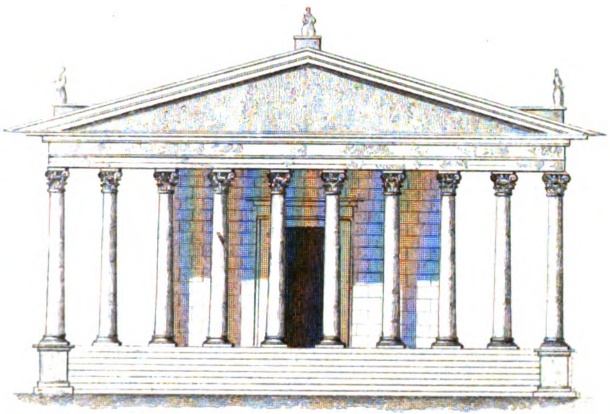
DORIC PORCH

Fig. 1



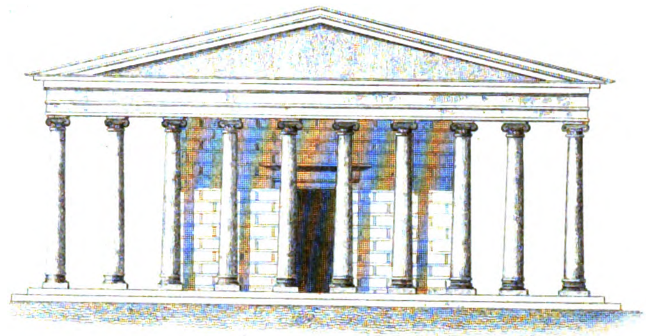
EGYPTIAN TEMPLE

Fig. 4.



ROMAN PORCH

Fig. 3.



IONIC PORCH

London. Published by William Orr, Paternoster Row Feb. 28. 1835.

Boötes. This star was known to the ancients, and is mentioned by Job, and also by Virgil.

ARCTUS, in *Astronomy*, a name given by the Greeks to two constellations of the northern hemisphere; by the Latins called ursa major and minor; and by us the greater and lesser bear.

ARCUATIO; a gibbosity of the fore parts, with a curvation of the bone of the sternum of the tibia, or dorsal vertebræ.

ARCUBALISTA. See BALISTA.

ARDASSES; a peculiar coarse kind of silk used in Persia.

ARDASSINES; the unwoven silk known under this name affords a striking contrast to that alluded to in the previous article. It is the finest used in the looms of France.

ARDOR VENTRICULA; a disease of the stomach, better known as *heart-burn*.

AREA, in *Geometry*, the superficial contents of any figure, as a triangle, quadrangle, &c., which is estimated by small squares, or parts of squares.

AREA, in *Architecture*, strictly a dry place, but more generally applied to the open space at the bottom of a house.

ARENA, an obsolete term for gravel in the human body.

ARENA, in *Architecture*, the whole internal plan of a temple.

AREOLA; the coloured circle round the breast.

ARES, an alchemical term descriptive of the great first cause.

ARGAL; crude tartar in the state in which it is taken out of empty wine-vessels.

ARGAND LAMP. See LAMP.

ARGEMA; a disease of the eye.

ARGENT, in *Heraldry*, a term used to denote the white colour of a shield, and in several terms of art employed by the goldsmiths to denote silver.

ARGENTUM ALBUM; a term anciently employed for silver money.

ARGENTUM MOSAICUM; an amalgam of tin, bismuth, and mercury, employed for colouring plaster of Paris.

ARGETENÂR; a star of the fourth magnitude in the constellation Eridamus.

ARGILLACEOUS; white pure earth. The argillaceous earths generally are the basis of earthenwares.

ARGO; a constellation in the southern hemisphere.

ARGUMENT, in *Astronomy*, any quantity or equation on which depends another quantity relating to the motion of the planets; or, in other words, it is an arc whereby another arc is to be sought, bearing a certain proportion to the first arc. The argument is of different kinds, namely—argument of inclination, or argument of latitude, the arc of a planet's orbit, intercepted between the ascending node and the place of the planet from the sun, numbered according to the succession of the signs. Menstrual argument of latitude is the distance of the moon's true place from the sun's true place, by which is found the quantity of the real obscuration in eclipses. Annual argument of the moon's apogee, the distance of the sun's place from the moon's apogee, that is, an arc of the ecliptic, comprised between these two places. Argument of the parallax, denotes the effect it produces on the observation, which serves for determining the true quantity of the horizontal parallax.

ARGYROPEA. The art of making silver by the alchemists.

ARIDED; a fixed star of the second magnitude in the Swan's Tail.

ARIDURA, in *Medicine*, a term employed to describe a general wasting of the body.

ARIES; one of the twelve signs of the zodiac. It is usually termed the vernal sign.

ARIES; the original name for the battering-ram. In tracing the progress of invention, it is curious to observe how much more rapidly the destructive arts advance than those which are intended for the benefit and real advantage of mankind. The hurling of a stone by manual strength was speedily succeeded by the sling, balista, and aries; and in the same way we find in the very infancy of the arts the Greek fire taking the place of simple bitumen, and that again superseded by gunpowder, which appears likely to be superseded by the transatlantic invention of high-pressure steam.

The aries, as an instrument for battering walls, is said to have been invented by Artemanes of Calzomene, a Greek architect who flourished 441 B. C. The machine is thus described by Josephus: "It is a vast beam, like the mast of a ship, strengthened at one end with a head of iron, something resembling that of a ram, whence it took its name. This was sometimes supported by men, and at other times hung by the middle with ropes to another beam, which lay across two posts; and hanging thus equally balanced, it was by a great number of men drawn backwards and pushed forwards, striking the wall with its iron head. But this engine did most execution when it was mounted on wheels, which is said to have been first done at the siege of Byzantium under Philip of Macedon." Plutarch informs us, that Marc Antony in the Parthian war made use of a ram fourscore feet long; and Vitruvius says, that they were sometimes 106 and sometimes 120 feet in length; and to this much of the force and strength of the engine was in a great measure owing. The ram was managed at one time by a whole century of soldiers; and they being spent were replaced by another century, so that it operated continually.

In the graphic delineation beneath, the *aries* is seen in operation in the foreground, supported on the shoulders of seven soldiers, and the men having given momentum to the ram by retreating a few steps, are supposed to be advancing to the attack and striking the stones with the whole weight of their bodies acting in unison with the ram head. It may be proper to observe, that the aries owed all its force to its being driven perpendicular to the surface of the stone.

We allude to this, as the artist has by a slight

misconception made it strike obliquely. At the back of this stirring scene a similar beam suspended by a chain is made to operate by piercing the wall with a pointed iron head.

Arish; a Persian measure of length containing about thirty-eight inches.

Arista, in *Astronomy*, an obsolete term for the spica virginis.

Arithmetic, the science whose object it is to investigate the relations and properties of numbers.

Of the origin and early progress of arithmetic we know nothing; the remotest source to which we can trace it is Egypt, whence it is said to have been brought to Greece by Thales the Milesian, about 600 years before Christ. The oldest treatise on the subject is that written by Euclid, the celebrated Greek geometer, and is contained in the seventh, eighth, and ninth books of his Elements.

The Greeks, in counting numbers, reckoned as we do by periods of ten; this we perceive, from the structure of the words of their language, used to signify numbers greater than ten. Thus the term for *eleven*, is a compound of *one* and *ten*; for *twelve*, of *two* and *ten*; and *thirteen*, *fourteen*, &c. up to *twenty*, are literally expressed by *three* and *ten*, *four* and *ten*; and so on. But though, in reckoning, the Greeks divided numbers into the same periods as we do, their method of representing them in a written form more concise than that of ordinary language, was totally different from ours. They were, it is well known, ignorant of our system of decimal notation, which may indeed be termed one of the simplest and most perfect of human inventions, as it enables us to represent any number, however great, by means of only ten characters.

The earlier marks employed to represent numerals were, of necessity, suited to the nature of the materials on which they were inscribed, and the quality of the instruments employed to trace them. In carving on pillars of stone, none but straight lines are capable of being cut with facility, and this remark applies still stronger to materials of wood. Hence the primary numeral characters, like the early forms of the letters of the alphabet, which are preserved with little variation in the capitals which we employ, were wholly of this nature. When this method was brought to some degree of perfection, the uniform broad strokes were dismissed, and the letters of the alphabet which most resembled their several combinations were adopted in place of them. But when the Greek alphabet was extended and improved by the introduction of the small characters, these were sometimes employed in their natural succession to signify the lower ordinal numbers, an arrangement which we observe in the heading of the books of the Iliad and Odyssey. The first letter, α, was the figure which they used to represent *one*; the second, β, denoted *two*; the third, γ, *three*, and so on, up to ω, or *twenty-four*, which was necessarily the limit of this notation. A second method consisted in the adoption of the initial letters of the words expressing certain numbers as representations of those numbers. Thus the Π of ΠΕΝΤΕ stood for *five*, the Δ of ΔΕΚΑ for *ten*, the H, which is the first letter of the aspirated ʽΕΚΑΤΟΝ, for an *hundred*, the X of ΧΙΛΙΑ for a *thousand*, and the M of ΜΥΡΙΑ for *ten thousand*. In order to extend this notation, a simple and ingenious device was resorted to; a large Π placed over or around any letter augmented its value five thousand times; thus |Δ|, denoted fifty thousand, and |H| five hundred thousand.

But a mighty improvement was afterwards effected by the Greeks in their arithmetical notation. The twenty-four letters of the alphabet were distributed into three classes, corresponding to units, tens, and hundreds; and to complete the characters for the nine digits, three additional marks were introduced. Thus the first eight letters with an additional character, represented the units; the next eight with an additional character, represented the tens; and the remaining eight with another additional character, the hundreds. This arrangement of the symbols it is obvious could extend only to the expression of the number nine hundred and ninety-nine; but by writing an *iota* under any letter, the value of it was augmented a thousand times. And by subscribing the letter M, the initial letter of the word signifying a *myriad* or ten thousand. A still further advance was made, and the power of the letters increased ten thousand fold. This latter object was sometimes more simply attained by placing two dots over the character, whose value was to be augmented.

Such is briefly the very beautiful and ingenious system of numeration which prevailed amongst the Greeks. It was on the whole remarkably compact, and, as an instrument of calculation, might be deemed sufficient for every practical purpose; but to fulfil the objects of science something more was necessary. The penetraating genius of Archimedes quickly suppiled the desideratum. In a curious tract, entitled *Arenarius*, this philosopher amused himself with showing, that it was possible, assuming the estimation of Aristarchus of Samos, and other astronomers of that age, to represent the number of particles of sand which would be required to fill the sphere of the universe. He took the limit of the ordinary numeral system, or ten thousand times ten thousand, that is, an hundred millions, as the root of a new scale of progression, which therefore advanced eight times faster than the simple decimal notation. Successive periods, which he termed *octads*, were thus formed rising above each other by the continued multiplication of an hundred millions. Archimedes proposed to carry this comprehensive system as far as eight periods, which would therefore correspond to a number expressed in our mode by sixty-four digits. From the nature of a geometrical progression, he demonstrated that proportional numbers would range at equal distances; and, consequently, that the product of any two numbers must have its place determined by the sum of the separate ranks, a principle which involves the theory of logarithms.

The fine speculation of the Sicilian philosopher does not, however, appear to have been carried into effect; and without actually performing those calculations, he contents himself with merely pointing out the process, and stating the approximate results. But Apollonius, the most ingenious and inventive, next to Archimedes, of all the ancient mathematicians, resumed that scheme of numeration, simplified the construction of the scale, and reduced it to a commodious practice. For greater convenience, he preferred the simple myriad as the root of the system, which, therefore, proceeded by successive periods, corresponding to four of our digits, and distinguished by breaks or blanks.

But the Greek notation was not adapted for the

descending scale. To express fractions, two distinct methods were followed; if the numerator were unity, the fraction was indicated by accenting the denominator; in other cases, the denominator was written a little above to the right hand of the numerator. The laborious operations required for the management of complex fractions gave rise to the sexagesimal arithmetic, the introduction of which, about the year 130, is commonly ascribed to Ptolemy. In this notation, which was suggested by the astronomical division of the circle, the integral numbers from one to 59, were expressed in the ordinary manner; 60 was called a *sexagesima prima*, and was denoted by unity with an accent placed over it; 120, or twice 60, was represented by *two*, accented; 240, or four times 60, by *four* accented, and so on till 3,600, or 60 times 60, which was called *sexagesima secunda*, and expressed by unity with two accents. Then 60 times 3,600, or 60 multiplied by itself twice, was represented by unity with three accents, and so on. If the number to be represented were not an exact multiple of 60, the portion of it which was the greatest multiple was written with its proper number of accents, and the excess was joined to it without any; thus 3,614 would have been expressed by writing the character for *one* with two accents, and annexing the number 14 written in the ordinary manner. The operations with sexagesimal fractions were performed in the descending scale on a principle quite similar to that which Archimedes had before laid down. Each period of the multiplier was multiplied into a period of the multiplicand, and this product was then thrown to a rank depressed as much as the conjoined descents of the two factors.

We have thus very briefly noticed the method of notation which was adopted by the Greeks; for a fuller account of that, and the systems employed by other nations, we must refer to the article NUMERALS. We may here however observe, that the great and radical defect of the Greek system consisted in the want of a general mark analogous to our cypher, and which without having any value itself, should serve to ascertain the rank or power of the other characters by filling up the vacant places in the scale of numeration. Had Apollonius classed the numerals by triads instead of tetrads, he would have greatly simplified the arrangement, and avoided the confusion arising from the admixture of the punctuated letters which were used to express thousands. The extent of the alphabet was favourable to the first attempts to represent numbers by symbols; since, with the addition of three intercalations, it furnished characters for the whole range below a thousand; but that very circumstance in the end proved a bar to future improvements. It would have been a most important stride to have next exchanged those triads into monads, by discarding the letters expressive of tens and hundreds, and retaining only the first class, which with its inserted character should denote the nine digits. The *iota*, which signified ten, now losing its force, might have been employed as a convenient substitute for the cypher. By such progressive changes, the arithmetical notation of the Greeks would at last have reached its utmost perfection, and have exactly resembled our own. A wide interval no doubt did still remain; yet the genius of that acute people, had it continued unfettered, would in time, we may presume, have triumphantly passed the intervening boundaries.

Our modern system of notation we unquestionably derived from the Arabians, who had themselves obtained this invaluable acquisition from their extended communication with the east. It seems to be pretty generally determined that the mode of expressing any number, however great, by means of nine significant characters, and a blank one employed to keep the others in their places, was known in Hindoostan as early as the sixth century, whence it was introduced into Arabia about the middle of the thirteenth, though some would refer it to an earlier date. The period of the introduction of these digits into Europe is a question which has occasioned much discussion. By some it is dated so early as the beginning of the eleventh century, while others are disposed to place it two hundred and fifty years later. As they were doubtless first used by astronomers, and afterwards circulated in the almanacks over Europe, Kircher with some air of probability would refer their introduction to the astronomical tables published by the celebrated Alphonso, king of Castile, in 1252. But it is suspected that in the original work the numbers were expressed in Roman or Saxon numerals, especially as two letters from the same monarch to Edward the First of England, which are preserved in the Tower of London, have the dates 1272, and 1278, still denoted by those ancient characters. One of the oldest authentic dates in the Arabic figures is that of the year 1375, which appears in the handwriting of Petrarch, on a copy of St. Augustine which had been in his possession. Although at that period the use of these characters was still confined to men of learning, it had already begun to spread in Europe.

We have said, that our mode of notation by nine significant characters and a blank one, was known as early as the sixth century in Hindoostan. There is little doubt but that the Chinese were acquainted with the system many centuries earlier; and it is remarkable, that while all the European nations have stopped at the ninth digit, the Chinese from the earliest antiquity have proceeded direct from one to ten, without the use of the zero or cypher, and employing no combination as the Europeans do. From ten they proceed thus:—ten and one, ten and two, ten and three, &c. Twenty is expressed by two and ten; twenty-one, by two ten and one, &c. They have characters expressive of hundred, thousand, and ten-thousand: hence, two hundred, two thousand, or two ten-thousand, would have the numeral *two* preceding it, or in their mode of placing the figures, *over* it, as they read from the top to the bottom of the page.

The first work on arithmetic, printed in England, is that of Cuthbert Tonstall, bishop of Durham. It is entitled *De Arte Supputandi libri quatuor*, and issued from the press of Pynson, in 1522. A copy upon vellum, supposed to have been Tonstall's own, and possessing his autograph, is preserved in the library of Corpus Christi College, Oxford. In 1585 appeared *La Pratique d'Arithmétique*, by Simon Stevin; to which was attached a treatise, entitled *La Disme*, in which decimal fractions were for the first time considered. Previous however to this publication, Peter Ramus had used decimal periods in performing the extraction of the square root of fractions; and according to Dr. Wallis, our countrymen Buckley and Recorde, had employed a similar method for the same purpose as early as 1550. But Stevin was undoubtedly the first author who professedly wrote on

this subject; his work was subsequently translated into English in 1608. The theory and notation of decimals were afterwards greatly improved by Baron Napier, in his *Rhabdologia*, and arithmetic was brought to its present state by the discovery of continued fractions, which was made by Lord Brounker in 1670, and which enabled him to approximate very near to the ratio of the circumference of the circle to its diameter.

NUMERATION.

The first elements of arithmetic are acquired by us during our infancy. A knowledge of our present mode of reckoning and writing numbers is attained at so early an age that we hardly recollect how we began. As soon as we are able to exercise our reasoning faculties, we find ourselves in the habit of counting by tens, and so simple and natural does the method appear, that without reflecting on the means formerly practised by nearly all the world, and still in use among savages for effecting the same object, we are induced to conclude that it arises from something inherent in the nature of numbers, and that we acquired it simultaneously with our ideas of them. But a little consideration will enable us to see the impropriety of such a conclusion.

The idea of numbers having been acquired, it is natural to suppose that our notions of those which most frequently present themselves should be more clear than of any others. The perpetual occurrence of objects singly and grouped in pairs, must render the ideas of *one* and *two* familiar to us; while of numbers, such as those which we express by the terms *twenty-three* and *twenty-four*, we cannot have any distinct apprehension. Hence, if we wished to convey an idea of them, we could only do so by saying that they bear a certain relation to the simpler ones.

The classification by pairs, which nature points out, would suggest the simplest mode of reckoning. Hence the dual, though also retained by the Greeks, occurs in the languages of all barbarous tribes. Counting these pairs again by twos and repeating the same process, we arrive by progressive steps at the numbers *four*, *eight*, and *sixteen*, &c., to which the other numbers are easily reducible. Thus *thirteen* being composed of *eight*, *four*, and *one*, would according to such a system of numeration be called "quadruple pair, double pair and one," or denominated more concisely by words of corresponding import. This plan of arrangement, termed the binary scale, seems at a certain period of society to have prevailed in most countries; and Leibnitz has extolled the system with abundant extravagance. It would no doubt from its naked simplicity supersede the application of thought, and reduce all the operations which occur in arithmetic to the mere labour of writing; but nothing would thus be gained in practice, since advancing with excessive slowness, it would soon require a multiplicity of words, and a fatiguing complication of characters.

The next step in the progress of numeration was probably to assume the double pair, or four, as the root of the scale. The ancient Mexicans appear to have reckoned by fours, and to have afterwards advanced in their numeration by combining the products of four with those of ten.

But nature has furnished the universal standard of computation in the fingers of the hand, the practice of counting by which must have been so familiar in the earlier periods of society. All nations accordingly have reckoned by *fives*, and after the fingers of one hand had been counted over, it was a second, and perhaps a distant step, to proceed to those of the other. The primitive words expressing numbers probably exceeded not five. To denote, *six*, *seven*, *eight*, and *nine*, the North American Indians repeat the *five*, with the successive addition of *one*, *two*, *three*, and *four*. Could we safely trace the descent and affinity of the abbreviated terms denoting the numbers from five to ten, it seems highly probable that we should discover a similar process to have taken place in the formation of those terms in the most refined languages; the structure of those denoting numbers above ten, sufficiently betrays the influence of the arrangement by that number in their formation.

The process of reckoning with the fingers of both hands having become general, we may conceive our present system of numeration to have been formed thus:—A man has to count a number; to accomplish this he makes use of his fingers, and for every *one* that he counts he lays down a finger on the table: when he has advanced to ten he has reckoned all his fingers, and can continue no further. Therefore if the number which he has to count be greater than ten, he must begin and reckon them over again; but before he can do so, it is necessary for him to mark in some manner that he has already reckoned them *once*, which he might otherwise forget. He does this, we suppose, by making another person put down *one* finger, and then proceeds himself to reckon all his own fingers a second time, when he will have counted a second ten. His companion immediately puts down another of his fingers, to denote that the other has once more reckoned the whole of his. This operation having been continued until the first person has reckoned all his fingers ten times, the second one will then have lain down ten fingers, and will be unable to proceed further. It becomes therefore necessary to employ a third person, who shall do for the second what the second does for the first; that is, mark by laying down *one* of his own fingers that the other has lain down *all* his. The second will thus be at liberty to recommence his registering of the operations of the first, and will be enabled to continue until he has again put down all his fingers, when he must stop until relieved by the third marking that he has done so, by laying down another of his. This operation is continued until the first person finds that the whole number is counted; he then perceives that he has got, say *seven* fingers down, that the second has *three*, and the third *eight*. Now as the first lays down a finger for every *one* that he counts, the seven fingers which he has down show that he has counted *seven ones*. But every finger which the second puts down denotes, not that he has counted one, but that the first has counted ten, which, being unable to mark them with his own fingers, he has employed those of the second to mark; therefore the three fingers which the second has down represent ten counted three times, or *three tens*. The third puts down one of his fingers every time that the second puts down all of his; but every finger which the second puts down represents a *ten*, therefore every one of the third must represent a ten of tens; and the eight fingers which he has down denote that a ten of tens has been reckoned eight times. Hence the

whole number which has been counted is seven ones, three tens, and eight tens of tens.

Such we may conceive to have been the original formation of our decimal scale of arithmetic, traces of which we may discern in the structure of language. If the primary import and composition of δεκα, ἑκατον, χιλια, and μυρια, the Greek terms for a *ten*, a *hundred*, a *thousand*, and a *ten thousand*, could be safely ascertained, we should doubtless discover the influence of the denary system in their formation. It is strongly marked in the composition of the names of all of the numbers between ten and twenty. But the origin of the names imposed on the radical numbers appears most conspicuously displayed in the nakedness of the savage dialects. The Muysca Indians, who formerly occupied the high plain of Bogota, in the province of Grenada, were accustomed to reckon first as far as ten, which they called *quihicha*, or a *foot*, meaning no doubt the number of toes on both feet, with which they commonly went bare and exposed; beyond this number, they used terms equivalent to *foot one*, *foot two*, &c., corresponding to *twelve*, *thirteen*, &c. Another tribe, which likewise inhabits South America, the Sabiconos, call *ten*, the root of the scale, *tunca*, and repeat only the same word to signify a *hundred* and a *thousand*; the former being termed *tunca-tunca*, and the latter *tunca-tunca-tunca*. Our own dialect, as immediately derived from its Gothic stem, betrays a composition not less rude or expressive than the simple articulation of the Sabiconos. According to the authorities collected by a celebrated German philologist, the late Adelung, the word *eleven* was most anciently written *einlif* or *einlivin*, being compounded of *ein*, or *one*, and the verb *liban*, to *leave*, and therefore signified merely *one, leave;* that is, retain *one*, and set aside, no doubt, *ten;* the root of the scale *twelve* has the same derivation. The names *twenty*, *thirty*, *forty*, &c., have the terminating syllable *ty*, which corresponds to *zig* in German, and *zug* or *zuch* among the oldest writers of that parent tongue. This termination is derived from the verb *ziehen*, to *draw;* and hence *twenty* means simply *two drawings*, *thirty*, *three drawings*, &c., intimating evidently that so many tens are drawn or separated from the heap to be counted. The term *hundred*, which also runs unvaried through all the branches of the Gothic, is formed of *hund*, which anciently signified only *ten*, and *red* or *ret*, a participle from the verb *reitan*, to reckon or place in rows. The compound would therefore intimate as much as *ten times told*. In the Gothic translation of the Gospels, made by Ulphilas in the fourth century, *one hundred* is expressed by *taihund-taihund*, or the word for *ten* merely doubled; exactly like the *tunca-tunca* of the Sabiconos of South America. But in the Anglo-Saxon version, which was made about three centuries later, *one hundred* is denoted by *hund teontig*, meaning *ten of ten drawings*. In the same curious monument of our early language, *hund seafantig*, or *ten of seven drawings*, is employed to express *seventy*. It seems probable that *hund* and *ten*, or *teon*, were only variations of the same word. The term a *thousand* is merely an abbreviation of *diuis-hund*, its earliest form. The prefix *diuis* is the same as the word *twice*, and *hund* was probably contracted for *one hundred;* the combined expression would therefore signify a *redoubled hundred*, or *one hundred repeated ten times*.

To return to our example. The man in question has counted the number which he required; let us suppose that his object in so doing has been to ascertain how many stones are contained in a certain heap. He is now enabled to convey to himself a notion of what the number of the heap is; for he has found that it is composed of seven single stones, three collections of ten stones, and eight other collections, each of which contains ten of those first collections, or eight collections of tens of ten; all numbers which are familiar to him and any one of which he can instantly present to himself by laying down so many fingers. This is not however the exact form of expression we now use: instead of a *ten of tens*, we say a *hundred*, and instead of a *three of tens*, we say *thirty*, and the whole number we should denote by *eight hundred and thirty seven*. But, as we have already observed, the original import of a *hundred* is equivalent to that of a *ten* of *tens*, and of *thirty* to that of a *three of tens*. As numbers were reckoned by tens, separate names were required for only *one*, *two*, *three*, &c.; *ten*, *eleven*, *twelve*, &c. were expressed by a compound which conveyed the notion of *ten* and *one*, *ten* and *two*, &c. But in consequence of the modifications which in the course of time our language has undergone, the structure of the word *eleven* no longer affords us a clue to its meaning. We learn indeed from an examination of the form in which it occurs in our parent tongue, the Gothic, that it originally did so; but to us, in its corrupted state, it has more of the appearance of a name arbitrarily chosen to represent the idea of the number which it expresses, than of a derivative or a compound. If all the words in our language which express numbers, had been preserved in their primitive structure and composition, without the slightest deviation from the form in which they were at first used, our system of numeration would explain itself. It is true that but a little of reflection or examination is even now required in order to render it perfectly clear and simple, but could the necessity of that little be avoided in acquiring the foundation of so elementary a science as arithmetic, a point of material advantage would be gained.

This method of expressing large numbers by means of a few names, is unlimited in its application; were it not so, our language would be imperfect. For numbers are infinite, that is to say, there is no *greatest* number, because however great a number may be, we can always by adding *one* to it obtain a greater; therefore we cannot say that we are able to give names to all numbers, unless we employ either an infinite number of isolated words to represent them, or a few which are susceptible of being combined to an unlimited extent. Of these the first is impossible; the other is the system we have adopted. As we express a *ten of tens* by a *hundred*, so a *ten of tens of tens* or a *ten of hundreds* is denoted by a *thousand;* a *ten of thousands* by a *ten thousand;* a *ten of tens of thousands* by a *hundred thousand;* and a *ten of hundreds of thousands*, or a *thousand of thousands*, by a *million*. This word we borrow from the French language, in which a thousand being denoted by *mille*, a thousand thousand is very regularly expressed by *million*. In like manner, as a thousand thousand is denoted by a *million*, a *thousand thousand thousands*, or a *thousand millions*, is expressed by a *bi-million* contracted into a *billion*, *bi* being the root of the Latin word *bis*, which signifies two. A thousand billions is a trillion, a thousand trillions a quatrillion, a thousand quatrillions a quintillion, and so on to sextillions, septillions, octillions, &c. The formation of these names is very regular;

thus, a *thousand thousand* or a *mille mille*, which is a *mille* redoubled once, is a *million*; a *thousand millions* or a *mille mille mille*, is a *bi-million* or *billion*, meaning a *mille* redoubled twice; a *thousand billions* or a *mille mille mille mille*, which is a *mille* redoubled three times, is a *trillion*, or a compound of *mille* with the root of the Latin word for *three*, and the termination *-ion*. The *quatrillion* is similarly formed, *quatr-* being the root of the Latin word for four; as are also the *quintillion, sextillion, septillion, octillion, nonillion*, &c., which contain respectively the roots of the Latin terms for *five, six, seven, eight, nine*, &c. The general principle observed in the formation of these compounds is this: as the numbers which they represent are the results of the reduplication of a *thousand*, or *mille*, a certain number of times, each of them consists of three parts: the termination *-ion*, which denotes that the operation of reduplication is to be performed; the word *mille* representing the number *on which* it is to be performed; and the prefix of the root of the Latin word which expresses *how many times* it is to be performed.

The inconvenience which, in reasoning upon numbers, would necessarily result from the use of their *names*, written at full length, has given rise to the employment of symbols or *figures*, to represent them in a shorter and more compact manner. It is evident that, as we can express in words all numbers by means of only ten separate *names*, we cannot require *more* than ten separate *symbols* to represent them in figures. But nine, as we shall see, are sufficient, and the characters which are employed for this purpose by almost all civilized nations are,

1, 2, 3, 4, 5, 6, 7, 8, 9,

which represent respectively,

One, two, three, four, five, six, seven, eight, nine.

The number eight hundred and thirty-seven would then be shortly expressed by 8 hundred, 3 tens, and 7.

The question which now occurs is, cannot we shorten this abridged form itself? Suppose that we denote the tens by marking their number with one accent, and the tens of tens, or hundreds, with two accents; the number will then be expressed by 8″3′7. Of course we are not bound to arrange the collections exactly in this order; on the contrary, any one of the following ways will do just as well: 8″73′, 3′8″7, 3′78″, 78″3′, 73′8″. But one certain method is all that we want, and in making a choice it is most natural to prefer an arrangement in which the different collections stand in the order of their magnitude, either the largest or the smallest being placed first, thus, 8″3′7, or 73′8″. Of these, the former is that which is universally adopted.

We now see why a separate charater for ten was unnecessary; it can be easily represented by 1′.

The use of these accents would naturally be extended to numbers beyond hundreds; thus, as we denote a ten by one accent, and a ten of tens, or a hundred, by two accents, in a similar manner we should represent a ten of tens of tens, or a thousand, by three accents, a ten of thousands by four, and so on. But it would soon be observed, that the accents were unnecessary; for as the figure with one accent would always be the second from the right, that with two accents, the third, and so on, it is evident that the place of each figure would determine how many accents were to be written over it. Therefore, if we put the figures in their right places, we may omit their accents; and thus the number 8″3′7 may be written 837.

But there are some numbers of such a nature, that if we arrange the collections of *one, ten*, &c., which compose them in the order of their magnitude, and give each its proper accent, the singly accented figure will not be the second from the right, nor the doubly accented one the third, &c. Thus six hundred and thirty would be expressed by 6″3′, in which 3′ is the first figure from the right instead of being the second, and 6″ the second instead of being the third. Therefore, if, in this case, we omit the accents, the place of each figure will not point out how many belong to it. The reason is plain; the number six hundred and thirty contains an exact number of tens; that is to say, if we were to distribute six hundred and thirty faggots into bundles of ten, there would be no single faggots left. But how are we to obviate the difficulty? What must we do in order to render our method of writing numbers general and uniform? The simplest plan which presents itself is this: as the difficulty arises from the collections getting out of the places appropriated to them, in consequence of its happening that there are no figures in some of the other places, let us bring them back by putting a figure in each of the empty places. But the figure which we employ for this purpose must not be one of those which we have already got, and each of which stands for a number, or we shall alter the value of the number which we want to express; therefore we must invent a new character.

The one which is commonly used is 0, the *cipher*, or *zero*, as it is called; and by subjoining this figure to 6″3′, we shall bring 3′ into the second place, and 6″ into the third. We may now, therefore, omit the accents, for the place of the figures *will* point out how many belong to them; and the number becomes 630. Again, in representing three thousand and four, or 3‴4, 3 ought to be in the fourth place from the right; we must, therefore, insert two blank characters in order to bring it there, or write 3004. Hence, in representing any number by figures, the following arrangement is adopted: write, in the first place, to the right the *ones*, or *units*, as they are also called; in the second place from the right, put the *tens*; in the third, the *hundreds*; in the fourth, the *thousands*; in the fifth, the *tens of thousands*; in the sixth, the *hundreds of thousands*, and so on. If there be no separate figure for any one of these collections, that is to say, if any one of them be absorbed, as it were, in one of the following, write in its place a 0, or cypher. The arrangement is exhibited in the example beneath:

2	6	8	0	7	9	5	0	2	8	3	6	4	0
tens of trillions.	trillions.	hundreds of billions.	tens of billions.	billions.	hundreds of millions.	tens of millions.	millions.	hundreds of thousands.	tens of thousands.	thousands.	hundreds.	tens.	units.

It may be observed, that there is a slight and simple abbreviation in the mode of reading a number of any considerable amount. Thus, in the above example, instead of reading two tens of trillions, six

trillions, eight hundred billions, seven billions, nine hundred millions, five tens of millions, two hundred thousand, eight tens of thousands, three thousand six hundred and forty, we use the words trillions, billions, millions, and thousands only once, and say twenty-six trillions eight hundred and seven billions, nine hundred and fifty millions, two hundred and eighty-three thousand six hundred and forty.

We now proceed to explain the elementary operations of arithmetic.

ADDITION.

When we have several numbers, and wish to ascertain or to express how many units are contained in them all taken together, we do it by *addition*. In considering this operation we shall have frequent occasion to speak of two numbers being added together; for the sake of convenience we shall denote this by means of a symbol. Thus, sometimes instead of saying that 8 *is to be added to* 4, we shall prefix to 8, or the number which is to be added, the sign of addition $+$, called *plus;* and then write it after 4, or the number which it is to be added to; as, $4 + 8$. We shall also make use of another symbol, namely, $=$, which is the sign of equality. Thus, whenever we wish to express that one set of numbers is equal to another, we shall employ $=$ instead of the words, *is equal to;* as, $2 + 2 = 4$, instead of 2 + 2 *is equal to* 4.

We may consider every number as formed by the successive addition of unity to itself. Thus, by adding 1 to 1 we obtain the number 2; by adding another 1 we get 3; or, in other language,

$$1 + 1 = 2$$
$$1 + 1 + 1 = 3$$
$$1 + 1 + 1 + 1 = 4$$
$$1 + 1 + 1 + 1 + 1 = 5$$
$$1 + 1 + 1 + 1 + 1 + 1 = 6,$$

and so on. The operation of addition in the ordinary sense, is only an abbreviation of this one. Instead of our object being to get a number which is only *one* greater than another, it is to find that which is *several ones* greater. Hence, as each step in the natural succession of numbers is 1, it is only necessary in adding two numbers, to count forwards from the one of them as many steps as are signified by the other. Thus, suppose that 5 is to be added to 8; reckoning onwards from 8, we pass through 9, 10, 11, 12, until at the fifth step we come to 13, which is therefore the *sum*, as it is called, of 5 and 8. This simple process may be more conveniently performed by counting with the fingers.

It is impossible, strictly speaking, to add together more than two numbers at a time. If we wish to ascertain the sum of several, we begin with finding the sum of the first and second; to this we add the third, and so on. Suppose that the sum of 8, 5, and 6 is to be ascertained; counting forward five steps from 8 we obtain 13, the sum of 8 and 5; and then ascending six steps from this we reach 19, which is therefore the sum of the three numbers. It is usual in finding the sum of more than two numbers, to perform the several additions mentally, and to note down only the result of the last. The progress of the learner will be greatly facilitated by committing to memory the accompanying table, which contains the sum (procured in this way) of every two numbers less than ten.

Addition Table.

	1	2	3	4	5	6	7	8	9
1	2	3	4	5	6	7	8	9	10
2	3	4	5	6	7	8	9	10	11
3	4	5	6	7	8	9	10	11	12
4	5	6	7	8	9	10	11	12	13
5	6	7	8	9	10	11	12	13	14
6	7	8	9	10	11	12	13	14	15
7	8	9	10	11	12	13	14	15	16
8	9	10	11	12	13	14	15	16	17
9	10	11	12	13	14	15	16	17	18

The construction and use of this table are very simple; the one number occupies the horizontal row at the top, and the other, the vertical column at the side, and the sum of the two will be found in the square which is common to the two rows headed by them. Thus, below the column headed by 8 in the top row, and in the horizontal range opposite to 5 stands 13, the sum of those numbers. Tables of this nature are seldom to be found but in the more ancient treatises on arithmetic; they are mentioned by Professor Leslie, in his admirable article on Arithmetic in the *Supplement to the Encyclopædia Britannica,* who observes that he thinks they have been very injudiciously omitted in the later systems of education. It is evident that the same benefits may be derived from their use which attend that of the ordinary multiplication table; for the object of both is the same,—to present in a compact form several results of a certain operation with the view to their being easily committed to memory.

The immediate application of the preceding method to numbers at all large is evidently impracticable; we therefore adopt another. Suppose that 27 is to be added to 32; 27 is 2 tens and 7 units, and 32 is 3 tens and 2 units; therefore, their sum must be 2 tens + 3 tens, and 7 units + 2 units, or 5 tens and 9 units, which we write 59. Again, let it be required to find the sum of 349 and 637;

349 = 3 hundreds + 4 tens + 9 units,
637 = 6 hundreds + 3 tens + 7 units.

Therefore,
349 + 637 = 3 hund. + 6 hund. + 4 tens + 3 tens + 9 units + 7 units, = 9 hund. + 7 tens + 16 units.
But 16 units we commonly express by 1 ten and 6 units. Hence,
349 + 637 = 9 hund. + 7 tens + 1 ten + 6 units,
or as 7 tens + 1 ten = 8 tens,
349 + 637 = 9 hund. + 8 ens + 6 units;
which we write 986.

We perceive then, that the addition of numbers greater than ten, consists simply of the repeated addition of numbers less than ten. We add together separately, first the units of each, then the tens, the hundreds, &c., and the several results thus obtained are the units, the tens, the hundreds, &c. of the sum. For further illustration we subjoin another example,

in which four numbers are to be added together. Let it be required to find the sum of 2519, 8540, 308, and 9347; for convenience we arrange the different collections of each sort in the same column.

2519 = 2 thous. + 5 hund. + 1 ten + 9 units,
8540 = 8 thous. + 5 hund. + 4 tens,
308 = 3 hund. + 8 units,
9347 = 9 thous. + 3 hund. + 4 tens + 7 units.

Therefore 2519 + 8540 + 308 + 9347
= 19 thous. + 16 hund. + 9 tens + 24 units
= 20 thous. + 7 hund. + 1 ten + 4 units
= 20714.

Having thus learnt the principle on which we proceed, we may now in practice omit the decomposition of each number into the collections of units, tens, &c. of which it consists. Thus having arranged the numbers in the following form,

2519
8540
308
9347
——
20714
2112

We need only add together the right hand column which contains the units of each of the numbers, and put down the result for the units' figure of the required sum. If however this result be greater than 9, it will be composed of two figures,—a units' figure and a tens' figure; in that case we must write in the sum only the former, and mark down the other on one side, or as we have placed it, beneath the first, in order that being a tens' figure it may be added to the collection of tens. In the present instance the result of the addition of the column of units is 24, or 2 tens and 4 units; we accordingly write down 4 for the units' figure of the sum, and mark the 2 beneath, remembering, however, that it does not stand simply for 2, but for 2 *tens*. There is no necessity for writing 2 *tens*, because it will be disposed of in the very next step we proceed to, which is the addition of the second column, or that containing the tens. The result of this second step is 9 tens; adding however the 2 tens before mentioned, it becomes 11 tens, or 1 hundred and 1 ten; we therefore write down only the 1 ten in the tens' place of the sum, and place beneath it the 1 hundred, which is to be joined to the collection of hundreds. The addition of the third column, that of the hundreds, gives 16, or joining the 1 hundred which we set aside in adding the preceding column, 17 hundreds, or 1 thousand and 7 hundreds. We therefore write 7 in the hundreds' place of the sum, and place beneath it 1, to be added to the thousands. Adding the third column which contains the thousands, and joining this 1 thousand, we obtain 20 thousands, or 2 tens of thousands. This leaves us no figure at all for the thousands' place, we must consequently place our blank character 0, there, in order that the next collection may fall into its right place, and write the 2 tens of thousands beneath. But as there is no collection of ten thousands to which to add it, we place it by itself in the ten thousands' place. The number thus obtained, 20714, is therefore the sum required.

As soon as a little practice is attained, the plan of writing down the numbers to be *carried*, as it is termed, beneath their corresponding figures in the sum may be discontinued; they can easily be retained mentally, as each of them is always to be added to the next column which is operated upon. We thus deduce the ordinary rule for the addition of numbers which are greater than ten: write the numbers to be added under one another, so that the units' digits shall be all in one column, the tens all in another, the hundreds all in another, and so on; add the numbers in the units' column, and write under it the units' digit of the sum, carrying the tens' digit to be added to the next column; cast up the tens' column with this addition, and write under it the units' digit of its sum, carrying the tens' digit to be added to the next column; proceed thus with every column till the last, under which write its whole sum.

SUBTRACTION.

When we have two quantities and we wish to find how many units will be left in one of them after the number of units in the other has been taken away from it, we ascertain this by performing the operation of *subtraction*. Just as we sometimes write the sign + before a number as a short way of expressing that that number is to be added to another, in a similar manner we employ the *sign of subtraction* —, to denote that the number to which it is prefixed is to be subtracted from another. Thus 8 — 5 is 8 *minus* 5, and means that 5 is to be subtracted from 8.

The object of this operation being precisely the reverse of that of addition, it is performed in a directly opposite manner; that is to say, beginning at that one of the two numbers from which the other is to be subtracted, or the *minuend* as it is called, we count *downwards* as many steps as are denoted by that other, which is termed the *subtrahend*. Thus, suppose that 5 is to be subtracted from 8; descending from 8 we pass through 7, 6, 5, 4, till at the fifth step we come to 3, which is therefore the *remainder* or *difference* required. The auxiliary table which we have given for ascertaining the sum of any two numbers less than ten, will evidently serve also to enable us to find their difference. For if 8 joined to 5 make 13, it is equally clear that 8 taken away from 13 must leave 5. The number 18 is the greatest sum in the table; therefore we can by reference to it find the difference between any number less than that, and any other less than 10. Thus, if we wish to find what will be the remainder after 6 has been subtracted from 14, we search in the row opposite to 6 in the left hand column until we find 14; the number 8, at the head of the column in which 14 stands is the remainder required. The reason is obvious.

As in the case of addition, the immediate application to large numbers of the principle of descending from the minuend, the number of steps denoted by the subtrahend, in order to find their difference would be so long and tedious a method as to be quite impracticable; hence a similar substitute is adopted. Thus, suppose that 345 is to be subtracted from 9587:

9587 = 9 thous. + 5 hund. + 8 tens + 7
345 = 3 hund. + 4 tens + 5

Therefore 9587 — 345
= 9 thous. + 5 hund. — 3 hund. + 8 tens — 4 tens + 7 — 5.

But if to 9 thousand we first add 5 hundred and then from it subtract 3 hundred, the effect is the same as if we only added 2 hundred to it. Similarly, if we first add 8 tens to it, and then take away 4 tens, we in effect only add 4 tens, and if we add 7 units and subtract 5, it is the same as if we added only 2 units.

Therefore

$9587 - 345 = 9$ thous. $+ 2$ hund. $+ 4$ tens $+ 2$
$= 9242$

The correctness of the principle on which we have proceeded is obvious; we have not taken the whole subtrahend from the minuend at once; for as we have before observed the numbers being large, that would be impracticable; but we have separated each into its component parts, and subtracted every one of the parts of the subtrahend from the corresponding part in the minuend.

It is of course impossible, from the nature of subtraction, to perform that operation unless the minuend be at least as great as the subtrahend. For instance, we cannot subtract 6 from 4; because it is impossible to take away from 4 more than there is in 4. But even although this condition be complied with, it may happen that one of the component parts into which we divide the subtrahend is greater than the corresponding part in the minuend; in other words, although the minuend have more hundreds in it than the subtrahend, and therefore be the greater number of the two, yet the subtrahend's collection of tens may be greater than that of the minuend. Thus, suppose that 784 is to be subtracted from 958,

$958 = 9$ hund. $+ 5$ tens $+ 8$ (minuend.)
$784 = 7$ hund. $+ 8$ tens $+ 4$ (subtrahend.)

Here there are 8 tens in the subtrahend, and only 5 in the minuend; therefore we cannot subtract the former collection from the latter. But 8 tens must be subtracted as well as the other collections composing the subtrahend; therefore how are we to remedy the difficulty? This is effected in a very simple manner by a method derived from the following principle: that we do not alter the difference of two numbers by increasing one of them, provided that we increase the other as much. Thus,

$$8 - 6 = 2$$

Now add 3 to each of the numbers 8 and 6, and then subtract them; or subtract $6 + 3$ or 9 from $8 + 3$ or 11; the difference is 2. Again add 4 to each; then $6 + 4$ or 10 subtracted from $8 + 4$ or 12 is still 2. Let us now apply this principle to our example. We have

$958 = 9$ hund. $+ 5$ tens $+ 8$ (minuend.)
$784 = 7$ hund. $+ 8$ tens $+ 4$ (subtrahend.)

Add 10 tens to the minuend, and in doing so, give them to that one of its collections which is deficient, that is to the tens' collection, which instead of containing 5 tens will then contain 15 tens. In accordance with our principle, we must also add 10 tens to the subtrahend; but as they are not wanted particularly in any one collection, place them in that to which they naturally belong, and which, as 10 tens is a hundred, is the collection of hundreds. Then introducing these alterations

$958 - 784 = 9$ hund. $- 8$ hund. $+ 15$ tens $- 8$ tens $+ 8 - 4 = 1$ hund. $+ 7$ tens $+ 4$;
or as we commonly express it, 174.

Again, 3495 is to be subtracted from 7002.

$7002 = 7$ thous. $+ 2$
$3495 = 3$ thous. $+ 4$ hund. $+ 9$ tens $+ 5$.

As 5 cannot be subtracted from 2, we add 10 to this latter, at the same time adding 10 to the subtrahend, which instead of 9 tens will thus have 10 tens. Proceeding, we find that we have no corresponding collection of tens to subtract these 10 tens from, we therefore add 10 tens to the minuend, at the same time adding 10 tens, or 1 hundred to the subtrahend, by which the 4 hundreds will become 5 hundreds. Continuing with the operation, we find also that we have no collection of hundreds to subtract these 5 hundreds from, we therefore add 10 hundreds to the minuend, and also to the subtrahend, which gives us in the latter 4 thousands instead of 3 thousands. We therefore have $7002 - 3495$

$= 7$ thous. $- 4$ thous. $+ 10$ hund. $- 5$ hund. $+ 10$ tens $- 10$ tens $+ 12 - 5$
$= 3$ thous. $+ 5$ hund. $+ 7$,

which we denote by 3507.

The whole operation then is simply this: Subtract each of the component collections of the subtrahend from the corresponding collection of the minuend; and if any one of those of the minuend be wanting, or not so great as the similar one of the subtrahend, make it as great by adding 10 of its own class to it; but to counteract the effect this would have on the whole remainder, add 10 of the same class to the corresponding collection of the subtrahend, or what is the same in effect, add one of the next highest class to the next highest collection of that number. Thus, if we add 10 units to the units' collection of the minuend, we must in return add what is the same as 10 units, namely 1 ten, to the tens' collection of the subtrahend; and if 10 tens be added to the tens' collection of the former, 1 hundred, which is equal to 10 tens, must be added to the hundreds' collection of the latter.

Having thus become acquainted with the principle of the operation of subtraction, we may now as in the case of addition, omit in practice the separation of the numbers into their component collections. The last example will then appear in the following form with the remainder beneath:

$$\begin{array}{r} 7002 \\ 3495 \\ \hline 3507 \end{array}$$

We commence with the units; as 2 is less than 5, we add 10 to it; then the subtraction of 5 from the sum 12, leaves 7, which we write in the units' place of the remainder. The next figure 9, with the addition of 1 to counteract the effect of the previous *borrowing*, as it is termed, or 10, is now to be subtracted; but as the corresponding collection in the minuend is wanting, we add 10; the subtraction leaves no figure for the remainder; we therefore put in 0; 1 carried to the 4 of the next collection in the minuend makes it 5, which taken from 10 (this 10 being borrowed) leaves 5; and 1 carried to 3 and subtracted from 7 leaves 3. Hence the whole remainder is 3507.

The reason of the ordinary rule will now be apparent: Write the subtrahend under the minuend, so that the units of both shall be in one column, the tens in another, the hundreds in another, and so on: subtract every figure in the lower number from the one over it in the upper, and write the remainder under it. When the figure in the upper is the smaller, add ten to it, observing at the same time to increase by 1 the next figure to the left in the lower number.

There is a method in use of subtracting numbers by means of what is called their arithmetical complement; in peculiar cases where several additions and subtractions are to be effected it furnishes us with a more expeditious mode of obtaining the result of them all by the performance of only one operation. For an account of it, see COMPLEMENT, *Arithmetical*.

MULTIPLICATION.

When the same number is to be added together several times, the addition assumes the name of *multiplication*. Thus, if 4 eights are to be added together, we say that 8 is to be *multiplied by* 4, or taken 4 times; and we may find the result, according to the ordinary rule, thus:—

$$\begin{array}{r} 8 \\ 8 \\ 8 \\ 8 \\ \hline 32 \end{array}$$

The number to be multiplied, 8, is called the *multiplicand;* the number by which it is to be multiplied, or that denoting how many times it is to be taken, 4, is called the *multiplier*, and the result of the operation, 32, is the *product*. The two former are also called the *factors* of the product, which is itself termed a *multiple* of each. As we employ the symbols + and — to represent the operations of addition and subtraction, we use × to denote that of multiplication. Thus 2 × 2 is a short mode of representing, 2 multiplied by 2.

It is evident that were the multiplicand and multiplier large numbers, the formation of their product by the repeated addition of the multiplicand would be an excessively tedious mode of operation; in order therefore to abridge it, we separate that number into its several component collections, and taking each of them individually the number of times denoted by the multiplier, we add together the various results, and the sum thus obtained is the product required. For instance, suppose that 23 is to be taken 4 times, or multiplied by 4; we shall evidently effect this by first taking 3, 4 times, and then taking 2 tens or 20 the same number of times, and the operation may be performed thus:—

$$\begin{array}{lcl} 2 \text{ tens} & + & 3 \\ 2 \;.. & & 3 \\ 2 \;.. & & 3 \\ 2 \;.. & & 3 \\ \hline 8 \text{ tens} & + & 12 = 92 \end{array}$$

In a similar manner we find the product of 5,348 by 6:—

$$\begin{array}{lclclcl} 5 \text{ thous.} & + & 3 \text{ hund.} & + & 4 \text{ tens} & + & 8 \\ 5 \;.. & & 3 \;.. & & 4 \;.. & & 8 \\ 5 \;.. & & 3 \;.. & & 4 \;.. & & 8 \\ 5 \;.. & & 3 \;.. & & 4 \;.. & & 8 \\ 5 \;.. & & 3 \;.. & & 4 \;.. & & 8 \\ 5 \;.. & & 3 \;.. & & 4 \;.. & & 8 \\ \hline 30 \text{ thous.} & + & 18 \text{ hund.} & + & 24 \text{ tens} & + & 48 = 32088. \end{array}$$

We can now therefore multiply any number however great, by any other which is less than 10; but, from the preceding examples, it must be apparent that our object would be greatly facilitated did we previously possess a knowledge of the product of every two of the first nine numbers. For instance, we should avoid the necessity of severally adding 6 eights, 6 fours, 6 threes, and 6 fives, if we already knew that the result of those operations would give 48, 24, 18, and 30. Hence it becomes a matter of importance to ascertain these products before proceeding any further; and for this purpose it is expedient to arrange them in a tabular form, so that they may the more easily be committed to memory. This table, the invention of which is ascribed to Pythagoras, is termed the multiplication table, and exhibits the product of any one of the nine first numbers by every one of them.

Multiplication Table.

1	2	3	4	5	6	7	8	9
2	4	6	8	10	12	14	16	18
3	6	9	12	15	18	21	24	27
4	8	12	16	20	24	28	32	36
5	10	15	20	25	30	35	40	45
6	12	18	24	30	36	42	48	54
7	14	21	28	35	42	49	56	63
8	16	24	32	40	48	56	64	72
9	18	27	36	45	54	63	72	81

The construction and use of this table are very simple. The first horizontal row contains the product of each of the first nine numbers by 1, and is of course formed by the repeated addition of unity; the second row contains the product of every one of the same numbers by 2, and is formed by the successive addition of that number; the third contains their products by 3, by the repeated addition of which it is formed, and so on. Hence, if we wish to ascertain the product of 6 by 4, we look in the fourth row, or that opposite 4, till we come to the sixth column, or that headed by 6, in which stands 24, the product required. We express this generally by saying that the product is found in the row opposite to the multiplier, and the column headed by the multiplicand.

In the sixth row and the fourth column stands 24, the product therefore of 4 by 6; and in the fourth row and the sixth column, as we have already found, stands also 24; hence the product of 4 by 6 is equal to the product of 6 by 4; or more shortly

$$4 \times 6 = 6 \times 4$$

By a similar inspection of the table we find that

$$5 \times 3 = 15$$
$$3 \times 5 = 15$$

Therefore,

$$5 \times 3 = 3 \times 5.$$

The same will be found to be the case with every pair of factors in the table; hence, in multiplying any two of the first nine numbers, it is immaterial which we make the multiplicand, and which the multiplier; for the result will be the same in both cases.

This remark we deduce from actual observation; we can show that it *is* true by trying it on any of the numbers in question; but we will now prove that it *must* of necessity be so, that it cannot be otherwise. Let us take the case of 5 and 3; write the figure 1 five times in the same line, and do this three times, placing the lines one beneath the other, thus:—

1, 1, 1, 1, 1,
1, 1, 1, 1, 1,
1, 1, 1, 1, 1.

This assemblage of units represents the product of 5 by 3, for it contains 3 rows of 5 units each, or 5

units repeated 3 times. But instead of reckoning the number of horizontal rows it contains, let us count the vertical columns; of these there must of course be 5, for each column is made up of 1 of the 5 units which are in each row; and as the number of rows is 3, each column must contain 3 units; therefore counting in this way, the assemblage contains 5 columns of 3 units each, or 3 units repeated 5 times, and represents therefore the product of 3 by 5. But as we have seen, the same collection represents the product of 5 by 3; hence the product of 5 by 3 must be equal to that of 3 by 5, which we find to be the case.

This mode of demonstration is evidently not confined to the particular numbers which we have applied it to; it may be extended to any whatsoever, by simply imagining a line to be formed containing 1 repeated as often as there are units in the multiplicand, and conceiving as many of these lines to be taken and placed one beneath the other as there are units in the multiplier. Reckoning the assemblage of units thus obtained by rows, it will, from the nature of its formation, represent the product of the multiplicand by the multiplier; but if we suppose it to be divided into columns, we perceive that there must be as many columns as there are units in each row, and that each column must contain as many units as there are rows; in other words, the assemblage must consist of a column containing as many units as there are units in the multiplier, repeated as many times as there are units in the multiplicand, and will represent the product of the multiplier by the multiplicand, if we may use the expression. But it also represents the product of the multiplicand by the multiplier; hence in multiplying any two numbers, it is indifferent which of them we make the multiplier; for the product obtained in both cases is the same.

We may in practice omit the decomposition of the multiplicand into its component parts, and when the product of any of its figures by the multiplier consists of more than one digit, instead of writing down the whole of the product, we put down, as in addition, only the units' digit, and carry the other to be added to the next product. The following example will illustrate this method, and afford us an opportunity of noticing a peculiar case of multiplication: suppose 3640 is to be multipled by 8; we write the multiplicand and multiplier under one another, as in addition, thus,

$$\begin{array}{r} 3640 \\ 8 \\ \hline 29120 \end{array}$$

We then multiply the first figure of the multiplicand, 4, by 8, which gives 32, or 2 to write down and 3 to carry; but as this 4 represents 4 tens, the product must of course represent 32 tens; we must therefore write 0 after the 2, in order that that figure may come into its right place. The product of 6 by 8 is 48, which, adding the 3 left to be carried at the last operation, becomes 51; writing down the 1, we carry the 5 to the next product 24, which thus becomes 29, the whole of which, it being the last product, we put down. We observe from this example, that in multiplying a number which contains one or more final cyphers, we commence with the first significant figure, and after finishing the operation, subjoin to the result the number of cyphers which are annexed to the multiplicand. In a similar manner, if any cyphers occur in the middle of the multiplicand, we must fill up the corresponding places in the product with the same number, unless indeed we happen to have a significant figure to carry to any one of them from the preceding partial product.

We may now perceive the reason of the following rule for the multiplication of numbers, when the multiplier consists only of a single digit:

Write the multiplier under the units' digit of the multiplicand; find in the table the product of the units' digit of the multiplicand by the multiplier; write the units' digit of this product immediately under the multiplier; find the product of the next digit of the multiplicand by the multiplier, add to it the tens' digit of the former product, write the units' digit of the number thus found, to the left of the digit last set down, and proceed as before.

The following may be taken as exercises:—To prove that $956 \times 6 = 5736$; $8200 \times 9 = 73800$; and that $7012 \times 5 = 35060$.

According to our system of notation, we increase the value of any figure 10 times by merely moving it one place further from the right; and as to multiply any number by 10, it is only necessary to render each of the collections of which it is composed 10 times greater, in other words to change its units into tens, its tens into hundreds, and so on: it is evident that we shall effect this operation by subjoining a 0 to the multiplicand, since by so doing we advance each of its significant figures one place further from the right. Similarly, we multiply a number by 100, by annexing to it 2 zeros; for we thus move each of its figures two places further from the right, and consequently increase their value 100 times. We therefore perceive that to multiply a number by 10, 100, 1000, 10000, &c., it is requisite only to attach to the right of the multiplicand as many zeros as are contained in the multiplier.

When the significant figure of the multiplier is greater than 1, the operation is decomposed into two separate ones. For instance, suppose that a number is to be multiplied by 500, or in other words by 100 times 5, we multiply it first by 5, and then increase the value of the product 100 fold, by subjoining 2 zeros to it. Thus, 347 is to be multiplied by 500,

$$\begin{array}{r} 347 \\ 500 \\ \hline 173500 \end{array}$$

The product of 347 by 5 gives 1735, to which we annex 2 zeros. We thus deduce the following general rule for the multiplication of a number by another, which consists of a single digit followed by one or more zeros: Multiply the multiplicand by the significant figure of the multiplier, and write after the product as many zeros as occur in the multiplicand.

This principle will apply to the case in which the multiplier is any number whatsoever, by considering separately each of the collections of which it is composed. Thus, suppose that we have to multiply 793 by 345, or to take 793, 345 times, that is, to take it 300 times, 40 times, and 5 times, and add the results together, or in other words to multiply it by 300, 40, and 5, and add the products together. This reduces the operation to three separate ones, all of which we can perform, because the multiplier has but one sig-

nificant figure in each. Arranging the numbers as in addition, we have

$$\begin{array}{rcl} 793 & & \\ 345 & & \\ \hline 3965 & = & 5 \times 793 \\ 31720 & = & 40 \times 793 \\ 237900 & = & 300 \times 793 \\ \hline 273585 & = & 345 \times 793 \\ \hline \end{array}$$

In this operation we multiply 793 successively by the collections of units, tens, and hundreds which compose the multiplier, observing, according to the rule we have given, to subjoin 1 zero to the product given by the tens, and 2 zeros to that given by the hundreds. The addition of the partial products gives the whole products required. But as the zeros which we have annexed, count for nothing in this addition, we may evidently dispense with writing them at all, provided that we take care to put into its proper place the first figure of the partial product given by each of the significant figures of the multiplier, that is to say, the product given by the tens' digit of the multiplier, in the tens' place, that given by the hundreds' in the hundreds' place, and so on.

From this we deduce the following general rule for the multiplication of any two numbers whatsoever: Write the multiplier under the multiplicand, units under units, tens under tens, &c. Write down the product of the multiplicand by the units' digit of the multiplier, observing that its units' digit shall be under the units' digit of the multiplier. In like manner write down the product of the multiplicand by the tens' digit, observing that its units' digit shall be under the tens' digit of the multiplier; proceed thus, and, when all the partial products are set down, add them up as they stand, for the whole product.

DIVISION.

The product of two numbers is formed by the repeated addition of one of them as many times as there are units contained in the other; in other words, the two factors are given, and the product is required. Suppose now that we have the product and one of the factors given, and that we wish to find the other; the second factor is simply the number which denotes how many times the first must be added to form the product; consequently we shall find it by subtracting the first factor from the product till we can subtract it no longer. For instance, if we wish to know how many times 16 must be added in order to make 64, in other words, how many times 64 contains 16, we have only to subtract 16 from 64 as often as we can; thus,

64
16 . . first subtraction.
—
48
16 . . second subtraction.
—
32
16 . . third subtraction.
—
16
16 . . fourth subtraction.
—
0

As we can only subtract 16, 4 times, we conclude that it is contained in 64, 4 times. Hence, in order to find how many times one number contains another, it is only necessary to subtract that other repeatedly from the first. The number of times this operation can be performed is the number of times required. But the application of this method to cases in which the one number contained the other a great many times would be exceedingly laborious; we therefore substitute a more compendious one, termed *Division*, analogous to the mode of abridging the repeated addition of the same number by means of multiplication, and alike suggested by the principle of numerical arrangement. This operation is then, strictly speaking, confined to large numbers, but it is usually, for the sake of uniformity, said to apply to all. Thus, in the preceding example, our object has been to *divide* 64, which is termed the *dividend*, by 16, or the *divisor*, in order to obtain the *quotient* 4; and the operation may be shortly denoted by writing $64 \div 16$, or, more commonly, $\frac{64}{16}$.

Again, suppose that we wish to divide 111 by 37:

111
37 . . first subtraction.
—
74
37 . . second subtraction.
—
37
37 . . third subtraction
—
0

As the remainder we obtain after subtracting 37 3 times is 0, we conclude that the quotient is 3.

It is evident that when the dividend does not contain the divisor as many as ten times, which can of course be easily ascertained by a simple inspection of the two numbers, and when the divisor consists of a single digit, the quotient may be found by reference to the table of products in the multiplication table. Suppose, for instance, that it is required to know how often 8 is contained in 56: passing down the eighth column in the table until we come to 56, we find that that number stands in the seventh row, or that opposite to 7, which is therefore its other factor, and denotes the number of times that it contains the first. We may perceive, by an inspection of the same table, that there are some numbers which cannot be exactly divided by others. For instance, as the seventh row, or that which contains the multiples of 7 does not include 40, therefore, it is evident that 40 is not a multiple of or divisible by 7; and as 40 lies between 35 and 42, both of which are multiples of 7, the greatest multiple of 7 that 40 can contain is 35, the factors of which are 5 and 7.

Let us now proceed to divide 1656 by 3; or, in other words, to find a number such that the multiplication of its units, tens, hundreds, &c. by 3, will give a product consisting of the units, tens, hundreds, &c. of the dividend 1656.

It is clear that this required number cannot contain a collection of any order higher than that of thousands, for if it had one of ten thousands, there would be also a collection of ten thousands in the product, which there is not. It is equally clear that it cannot contain a collection of so high an order as that of thousands, for if it had only one thousand, the product

would contain at least 3 thousand, which is not the case. Hence the thousand of the dividend must necessarily result from the multiplication of the hundreds' collection of the quotient by 3; therefore we shall obtain the number of the hundreds contained in the quotient by dividing that of the hundreds of the dividend by three. But 16 is not divisible by 3; we therefore find the greatest number in it which is, in other words, its greatest multiple of 3, which is 15, and the quotient of this by 3 is 5. But 5 hundreds, multiplied by 3, gives 15 hundreds, and the dividend 1656 contains 16 hundreds; hence the difference, 1 hundred, must have entered into the dividend in consequence of being *carried* over from the tens' place, in the formation of that number through its multiplication by the divisor. If now, from the whole product, we subtract what we have found to have been one of the partial products obtained during the performance of that operation, namely, 15 hundreds, or 1500, the remainder, 156, will contain the products of the units and tens of the quotient by the divisor; and therefore all we have to do now is to find that number, the multiplication of whose units and tens by 3 will give 156—a question precisely similar to that we originally set out with.

Having found the first figure of the quotient of this second dividend, in a similar manner to that in which we found it in the former case, we subtract its product by the divisor from the dividend, and the remainder which we obtain we make a third dividend, upon which we operate as upon the two preceding. We continue this method until we have no remainder left of which to make a dividend, when we have subtracted the divisor from the original dividend as often as we can, and therefore have finished the operation.

The following is a connected view of the operation.

$$\begin{array}{rrl}
\text{(dividend)} & 1656 & \left.\right\} \ \underline{\ \ 3} \ \text{(divisor)} \\
 & \underline{1500} & \left.\right\} \ 552 \ \text{quotient} \\
 & 156 & \\
 & \underline{150} & \\
 & 6 & \\
 & \underline{6} & \\
 & 0 &
\end{array}$$

The arrangement of the divisor and dividend is perfectly arbitrary; that which we have followed is the most convenient as facilitating the mental multiplication of the divisor by the figures of the quotient.

Let us take another example:

$$\begin{array}{rl}
1535 & \left.\right\} \ \underline{\ \ 5} \\
1500 & \left.\right\} \ 035 \\
\underline{35} & \\
0 &
\end{array}$$

Here we perceive that upon subtracting the 1500, or the product of the hundreds' figure of the quotient by 3, we obtain for remainder only 3 tens and 5; now 3 tens not being divisible by 5, we can have no tens' figure in the quotient, we must therefore write a 0 in the place of that collection, in order that the other collections may fall into their right places. Hence, whenever we obtain a partial dividend which is not divisible by the divisor, we must insert a cypher in the place appropriated to its collection in the quotient. The rest of the operation is as usual.

Let us now proceed to a case in which the divisor consists of more than one digit, for instance, the division of 57981 by 251. The quotient evidently cannot contain any collection of a higher order than that of hundreds; and the number of that collection which it does contain, must be such that, multiplied by 251, it may give 579 hundreds, or the nearest multiple of 251 below that number, which 579 contains. It is therefore 2; but the product of 2 hundreds by 251 is 502 hundreds, and the dividend contains 579 hundreds; the difference, 77 hundreds, must enter into the dividend by having been *carried* over through the multiplication of the tens and units of the divisor by the quotient. Subtracting the partial product 502 hundreds, or 50200 from the whole product 57981, we obtain the remainder 7781, which must contain the products of the tens and units of the quotient by the divisor; therefore, having found the hundreds of the quotient, all that we now have to do is to find a number which, multiplied by 251, will give 7781. To effect this, we proceed as before, and find the first figure 3 of this second quotient; multiplying the number which it expresses by the divisor, and subtracting the partial product thus obtained from the whole product 7781, we procure a remainder 251, which is the product of the units' figure of the quotient by the divisor. In this we proceed as before, until the whole operation is finished. The following exhibits a connected view of it:

$$\begin{array}{rl}
57981 & \left.\right\} \ \underline{\ 251} \\
\underline{50200} & \left.\right\} \ 231 \\
7781 & \\
\underline{7530} & \\
251 & \\
\underline{251} & \\
0 &
\end{array}$$

We find the successive digits in the quotient by guessing at them as well as we can. When we multiply the divisor by the digit guessed, if the product be greater than the partial dividend, the digit is too great; when we subtract, if the remainder be greater than the divisor, the digit is too small.

From these various considerations we may perceive the reason of the ordinary rule for the division of any one number by any other: Write the divisor on the right hand of the dividend; from the left of the dividend mark off the smallest number of digits that make a number not less than the divisor, find by trials the greatest number of times that the divisor is contained in this period, and write the result for the highest collection of the quotient beneath the divisor, but separated from it by a line: multiply the divisor by this digit, and subtract the period from the period marked off; bring down to the right of the remainder the next digit in the dividend, and proceed with the number thus formed as with the first period, writing the result as the second digit in the quotient: and proceed in the same way to find the other digits of the quotient.

The subject of Arithmetic will be continued under the articles, *Whole Numbers, Measure, Fractions, Decimal Fractions*, &c.; and the application of the science to the purposes of commerce will be explained under the heads of *Compound Numbers, Rule of Three, Interest*, &c.

ARITHMETICAL MACHINE. The various popular instruments employed for arithmetical purposes have been described and illustrated under our article

ABACUS; under which head our readers will also find an account of Mr. Babbage's extraordinary calculating instrument.

ARITHMETIC, *harmonical*, is that part of the doctrine of numbers which relates to the comparison, reduction, &c., of musical intervals.

ARITHMETIC, *specious*, is that which gives the calculus of quantities; using letters of the alphabet instead of figures to denote the quantities; and coincides with what we usually call algebra, or literal arithmetic. Dr. Wallis has joined the numeral with the literal calculus; and by means of it demonstrated the rules for fractions, proportions, extraction of roots, &c., under the title of *Elementa Arithmeticæ*.

ARM. See ANATOMY and BRACHIUM.

ARM, *fore*, that part lying between the elbow and the wrist.

ARM *of a horse;* the fore thigh.

ARM; each extremity of a bibb or bracket.

ARM *of an anchor;* that part of an anchor to which the palm is welded.

ARMENIUS LAPIS, or ARMENIAN STONE; an opaque sort of stone of a greenish blue colour, like the lapis lazuli. It is used as a purgative.

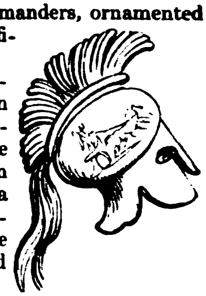
ARMENIAN BOLE; a native bole or earth brought from Armenia, commonly called bole armoniac. It is a fat kind of earth of considerable use as an absorbent and astringent.

ARMILLARY SPHERE; an artificial sphere so called from armilla, a bracelet, or ring, because it is composed of a number of circles of metal, wood, or paper, representing the several circles of the sphere of the world, put together in their natural order. For a more particular description of this instrument and its use, see ASTRONOMY.

ARMILLARY TRIGONOMETER; an instrument invented by Mr. Munro Murray, and improved by Mr. Ferguson, consisting of five semi-circles divided and graduated so as to solve many problems in astronomy.

ARMS. Man has not, like many animals, received from nature any member intended particularly as a weapon. He is obliged to use artificial means to increase his strength when he attacks, as well as to screen his body, which nature has left unprotected. Arms were, therefore, an early invention; perhaps, in the first instance, as a means of defence against animals. They were soon used, however, for the purpose of conflict between man and man. The first and most natural of all arms are the club and the sling. Every one naturally uses missiles as means of offence, and the sling adds force to the cast. In the history of the arms of all nations, we find invariably that man, beginning with the means of injury in the close struggle, endeavours continually to invent weapons which shall take effect from greater and greater distances. In consequence of the progress made in this way, dexterity always takes at last the place of courage. Nature has given to man only one weapon, in a limited sense of the word—the arm, used in boxing; and this can be made truly a weapon only by the dexterity acquired by long training. The art of boxing, moreover, is of use only against men. Within its sphere, indeed, it is very effectual. As soon as men learned the use of the metals, they worked them into pikes, spears, lances, and soon afterwards into swords and armour. Of this last, part only was at first made of metal, but the proportion went on increasing till at last a complete suit of iron came into use. The first improvement on the sling and the bow was the cross-bow. Still later came the large engines employed by the ancients, and called *catapultæ*, *balistæ*, &c. These would produce effect at the distance of 1000 feet. But the discovery of gunpowder changed the character of arms. Objects 6000 paces distant could now be reached, and obstacles overthrown with ease, the destruction of which formerly cost the labour of years. But the early defensive armour is much too curious to be passed over with this brief historical notice, and we propose to describe the principal arrangements adopted for this purpose both amongst the Greeks and Romans as well as our own ancestors. We cannot do better than commence with the helmet, especially as we find one very similar to the earliest of which we have any authentic record, employed in some of our horse regiments in the present day.

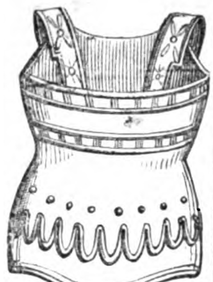
The Roman helmets, though commonly distinguished by the elegance of the Grecian, were of various forms; and those of commanders, ornamented with mythological and other figures of gold in high relief.



One of the simplest of these decorated helmets is represented in the annexed engraving, and combined with the splendour of the other equipments of the Roman legions, must have given them a very imposing aspect, which undoubtedly had its influence on the minds of their less civilized and more simple opponents.

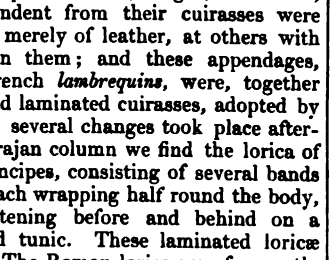
The round decorated helmet, with chain-mail attached for the protection of the neck, though for ages a most important part of the defensive armour of the knights of every nation of Christendom, was probably of eastern origin, and might have been introduced into more western countries by the Crusaders. A very beautiful illustration of the form of an eastern helmet is given in the accompanying figure. Plain round helmelts appear, however, to have been worn occasionally by the Roman gladiators, and to have formed part of the defensive armour of the common soldiery in most nations of Europe in later ages, and even in England so late as the seventeenth century. But the changes in military tactics, by the improvements in artillery and fire-arms, have caused the abolishment even of this last vestige of the heavy armour of our forefathers. We of course except the helmets worn in some of our horse regiments, to which allusion has already been made.

The ancient body armour was picturesque in its appearance, but not so well caculated for resisting a missile weapon as that worn by our horse-guards and lancers in the present day. In the earliest forms wood and the skins of animals were resorted to, and the latter of these materials was rendered so hard by exposure to the wind and sun, that we are told by a distinguished classic author, that the lance could not pierce the wearer. Horsehair was also employed for the protection of the body, and though not fitted to resist a direct thrust, effectually protected the soldier from the action of any cutting instrument. It was also very light. The cuirasses were made of folded linen or cloth; brass and iron were



most commonly of two pieces, and joined by a buckle at the shoulders, as in the accompanying wood-cut. These were altered, through their heaviness, to plates upon leather or cloth; and both these and chain-mail, but not interlaced, says Dr. Meyrick, also occur. Gold plates distinguished the Greek and Roman generals. The soldiers on the Trajan column wear a short leathern tunic, like a waistcoat, upon which plates of metal were sewed. The plates were sometimes superseded by small chains. The Etruscan cuirasses were plain, scaled, ringed, laminated, or quilted. Dependent from their cuirasses were straps, sometimes merely of leather, at others with pieces of metal on them; and these appendages, termed by the French *lambrequins*, were, together with their plain and laminated cuirasses, adopted by the Romans. But several changes took place afterwards. On the Trajan column we find the lorica of the hastati and principes, consisting of several bands of brass or steel, each wrapping half round the body, and therefore fastening before and behind on a leathern or quilted tunic. These laminated loricæ were very heavy. The Roman lorica was frequently enriched on the abdomen with embossed figures, on the breast with a Gorgon's head for an amulet, on the shoulder-plates with scrolls of thunder-bolts, and on the leather border which covered the top of the lambrequins, with lions' heads formed of the precious metals. The compact cuirass was made to open at the sides, where the breast and back plates joined by means of clasps and hinges.

Dr. Meyrick observes, that in ancient times the shape of the shield had much to do with the mythology of the people, and therefore were circular to represent the sun, and crescent-like to imitate the moon; of this latter species of shield, from its great rarity, we give a figure.



The ivy-leaf was sacred to Bacchus, and it is most probable that the Greeks derived the pelta, which Xenophon describes as of the same form to his earliest worshippers. The first shields were of basket-work, to which succeeded light wood. Ox leather, covered with metal plates, was however the most useful material. The middle had a plate of metal, often furnished with a thread of metal, turned in a circle or spirally. At first the shield was carried by a piece of leather, suspended from the neck over the left shoulder. This apparatus often appears upon Etruscan monuments. The handles of shields, says Herodotus, were inventions of the Carians. When, after war, the shields were suspended in the temples, the handles were taken away to prevent their being of service in sedition. Æschylus says, that bells were sometimes added to shields to affright enemies by the sudden sound, but Dr. Meyrick could not discover a single specimen. The Peloponnesians engraved their initials upon their shields, in order to distinguish themselves in battle. In a similar manner upon their coins there often occurs only a monogram of the two first letters of their names.

We come now to our own country, and it may in this division of our subject be advisable to go somewhat more into detail.

The arms in use among the ancient Britons were slight, and unfit to withstand the Romans in a close encounter; though in light skirmishes, prudently made, the Britons generally gained considerable advantage. Their young men were not only trained to the use of arms in early youth, but continued in the exercise of them for a very long period; and were always ready to appear, when called by their leaders into actual service. Their very diversions and amusements were of a martial and a manly cast; and the javelin they used in hunting was a principal weapon in the field of war. They had neither helmets, breastplates, nor defensive armour, but a light shield. Cæsar tells us they had a dart or javelin, which they threw from their war chariots to annoy the enemy; with a short spear for the infantry, that had a ball at the nether end filled with brass; this they shook with great violence before the battle, in hope to intimidate the enemy; and again, when they engaged the cavalry: to the upper end of it a thong was fixed, that when used as a missile weapon it might be recovered, and again used in the close encounter. They had also long and broad swords, without points, designed only for cutting, which were slung by a chain over the left shoulder; and occasionally a short dirk fixed in their girdles. The scythes that were sometimes fastened to their chariot wheels, may be ranked among their offensive arms.

The ancestors of the Saxons, in their native woods, we are told, transacted no business, public or private, without being completely armed; and the custom of wearing swords on all occasions prevailed in every country of which the Germans took possession.

The early Saxons, previous to their arrival in Britain, beside the buckler and the dagger, used a sword bent in the manner of a scythe; but their descendants soon changed it for one that was long, straight, and broad, double-edged, and pointed.

The Saxon infantry were not all furnished with the same offensive weapons; some being provided with spears, others with axes, and not a few with clubs, beside swords, which were common to them all. Their shields were generally of the middle size, for the most part oval, always convex, and having a sharp spike projecting from the centre; with which, while they defended themselves, they annoyed their enemies. They fought with their swords and shields, much like the gladiators of the Romans; and in the earliest times had nothing like defensive armour, which they seem to have adopted about the eighth or ninth century. Some alteration in our national arms probably took place on the arrival of the Danes. Their swords were both longer and larger than the Saxon swords; the lance had a slight difference; and they appear to have brought the battle-axe into more general use. Verstegan enumerates the cross-bow as a Saxon weapon, but had no good authority for the assertion; as it neither appears in any ancient history or delineation, that the Saxons ever were acquainted with it. And though they used the common bow when following the chace, they never brought it to the field of battle. Their cavalry were armed with greater uniformity than those who fought

on foot; carrying in their right hands long spears, and at their left sides a sword. They were also better provided with defensive armour.

Arms, in *Heraldry*, are usually connected with the rank or history of the bearer. It implies, any coats of arms; any signs of arms, or armour, painted on shields, targets, banners, &c.

Arms are of various kinds, as arms of dominion, borne by kings and emperors.—Arms of pretension, borne by sovereigns who are not in possession of the dominions they represent; as the arms of France, formerly quartered in those of England.—Arms assumptive; such as a man may of right assume with approbation of his sovereign. Arms of patronage; such as governors of provinces, &c. add to their arms. —Arms of alliance; such as are taken by the issues of heiresses to show their descent, paternal and maternal.—Arms of succession, taken by those who inherit certain fiefs or manors.—Arms of adoption; those taken from another family to be quartered with the paternal one.—Arms paternal and hereditary; such as are transmitted from the first obtainer to his son, grandson, great-grandson, &c.—Arms of concession; augmentations granted by sovereigns.—Arms canting or allusive, whose figures allude to the names, professions, &c.; as, a trevet for a person named Trevet, three cups for one named Butler, &c. We may cite one instance, to shew the importance which our ancestors attached to these almost "bygone distinctions." We allude to the celebrated case of Sir Richard le Scrope against Sir Robert le Grosvenor, in the reign of Richard II., about a coat of arms, viz. *azure* a bend *or*. This case was tried before the Constable and High Marshal of England, and others commissioned for the purpose. After the evidence of a large portion of the nobility and gentry, the sentence of the court (at the end of three years) was, that Sir Robert le Grosvenor should bear the said arms with a bordure, argent: who thinking himself injured by that sentence, appealed to the king, before whom, by his commissioners, the whole pleadings were reviewed; and at length it was decided that Sir Richard le Scrope should continue to use the same arms, and that Sir Robert le Grosvenor should use the said arms with a bordure, as in the sentence, or else instead of a "*bend, or,*" he might bear "*a garb, or,*" from his consanguinity to the Earls of Chester; whereupon Sir Robert ever after bore for his arms "*Azure a Garb, or,*" and the same have continued by his descendants to this day, of whom the present Earl Grosvenor is one.

Arnabos; an aromatic drug, sometimes employed as a substitute for cinnamon.

Arnaldia; a disease formerly known in England, one of the symptoms of which was a loss of the hair.

Arnotta; a drug of which a good deal is used in this country for the purposes of the dairy. Cheese dyed with it is said to have its flavour as well as its colour improved by the mixture. The arnotta employed by the dyers is of a dark red colour. It is formed from the pulp of the bixa.

Arnulphin; a coin formerly used in France. It was estimated at about a ducat and a half.

Arroba, or Arrobe; a variable weight used in Spain and Portugal. In the former country it is equal to 25, in the latter to 32 of their respective pounds. It is also a Spanish liquid measure, which, as regulated for wine, &c. by the standard of Toledo contains 1237¼ Spanish, or 981 English cubic inches, and equals 8 azumbras, or 32 quartillos. The arroba menor, or arroba of oil, measures 966¾ Spanish, or 771 English cubic inches, and is divided into 4 quartillos. The arroba is a name also given to one of the corn measures of Morocco.

Aroph; a term employed by the ancient alchemists, both for saffron, mandragora, and chemical flowers.

Aroura; a Grecian measure of length amounting to fifty feet.

Arpeggio, in *Music*. This term, which is of frequent occurrence, implies that the tones should be sounded distinctly, beginning at the lowest.

Arpent; a French measure of 100 perches.

Arquatus Morbus; the ancient name for jaundice.

Arquebus. This missile weapon was sometimes employed in the hand, and at other times used for the defence of a fort. It had a matchlock.

Arquebusade. A water under this name has long been fashionable, both as a medicine and a cosmetic. One of its principal ingredients is alcohol.

Arrache', in *Heraldry*; a representation of a plant torn up by the roots.

Arrest, in the *Veterinary Art*; a disease seated between the ham and posteria.

Arrhaphon; a skull in which the bones are unconnected by sutures.

Arriagi; the ancient name of camphor.

Arrondee, in *Heraldry*; a cross, consisting of sections of a circle, the whole of the curves being in the same direction.

Arrotino; a celebrated marble figure now at Florence, the history or design of which is involved in obscurity.

Arrow; the well known missile which is discharged from a bow, the pointed part of which is called the arrow-head. Bundles of arrows are called sheaves.

Arrow Stick. A rod employed in surveying.

Arschin; a Chinese measure of length, equal to two feet eleven lines.

Arsenic is a metal of very common occurrence, being found in combination with nearly all of the metals in their native ores. It is of a bluish-white colour, readily becoming tarnished on exposure to air, first changing to yellow, and finally to black. In hardness, it equals copper, is extremely brittle, and is the most volatile of all metals, beginning to sublime before it melts. Its specific gravity is 5736. It burns with a blue flame and a white smoke, emitting a strong smell of garlic. It commonly bears the name of *black arsenic*, and is prepared from the white arsenic of commerce, by heating this substance with carbonaceous matter, and allowing the volatile arsenic to condense in an adjoining vessel. Arsenical pyrites, a very abundant natural substance, is also advantageously used in the preparation of arsenic, in which case iron filings and lime are added, to engage the sulphur, and prevent its sublimation along with the arsenic. Native arsenic has been found in the veins of primitive rocks in several countries, but in small quantities, and generally alloyed by the presence of iron, silver, or gold. This metal is used in metallic combinations, when a white colour is desired. With oxygen, arsenic forms two compounds, both of which, from their property of combining with alkaline and earthy bases, are called *acids*. The

arsenous acid, the most important of the two, is the *white arsenic* of the shops. It is usually seen in white, glassy, translucent masses, to which form it is reduced by fusion from a powdery state. It is one of the most virulent poisons known, not only when taken into the stomach, but when applied to a wound, or even when its vapour is inspired. It is found native in small quantities, but is obtained for use from the roasting of several ores, particularly from that of cobalt and arsenical pyrites. The arsenous acid is condensed in long horizontal chimneys leading from the furnaces where these operations are conducted, and usually requires a second sublimation, with the addition of a little potash, to deprive it of any sulphur it may contain. Its manufacture has been chiefly confined to Bohemia and Hungary. Persons brought up from their youth in the works live not longer than to the age of 30 or 35 years. Knowing the deleterious nature of their occupation, they are so careless, that we have seen them cleaning their plates, &c. in wells, over which a skull was painted, to warn every body that the water contained arsenic. Besides its use in medicine, and as a ratsbane, it is much employed as a cheap and powerful flux for glass; but, when too much is added, it is apt to render the glass opaque, and unsafe for domestic use. Arsenite of potash, mingled with sulphate of copper, affords an apple-green precipitate, called *Scheele's green*, which, when dried and levigated, forms a beautiful pigment. With sulphur arsenic forms likewise two definite compounds—the realgar and orpiment. The former of these contains the smallest proportion of sulphur, and is red; the latter is yellow. They are both found native in many countries, but their supply in commerce depends upon their artificial manufacture. This is done by distilling a mixture of arsenical pyrites and iron pyrites, or of white arsenic and rough brimstone. Realgar or orpiment is obtained as the proportion of sulphur employed is greater or less. These compounds afford valuable pigments to the painter.

Arsenal; military depôt.

Arsenical Magnet; a preparation of antimony, sulphur, and arsenic.

Arshin; a Russian measure of length, equal to 315 French lines. The Chinese Arschin amounts to 302 lines.

Arsura; a classical term for the powder of a silversmith's workshop. The term was also employed by the alchemists for their dust of silver.

Arsura; the ancient name for erysipelas.

Arthritis; see Gout.

Arteriosa Vena; the pulmonary artery.

Arteriosus Canalis; a tube leading to the heart in the human fœtus.

Artery. This term is employed to describe the conical tubes which convey the blood from the heart to the various parts of the body. The arteries consist of three coats; the external, containing blood-vessels; the middle, consisting of elastic fibres, that contract and dilate; and the internal, which is a fine dense membrane that supports the fibres. By the circulation of the blood through the arteries, is produced the particular motion called the pulse, which arises from the alternate dilatation of the arteries, called the diastole, and their contraction, called the systole. The time which the fibres of the arteries take in performing their systole, that is, their return to their natural state, is the distance between two pulses. The heart discharges the blood into two great blood-vessels, called the arteria pulmonalis and the aorta.

The arteria pulmonalis, or pulmonary artery, rises from the right ventricle of the heart, and dividing itself to the right and left, carries the blood by innumerable ramifications through the lungs.

The aorta goes from the left ventricle of the heart, and is divided into the aorta ascendens and the aorta descendens. The aorta is called ascendens from the point where it leaves the heart to its great curvature or arch, from which it is principally distributed to the thorax, the head, and the upper extremities. The aorta descendens is the remaining part of this trunk from the arch to the os sacrum, or the bifurcation. It is distributed to the diaphragm, abdomen, and lower extremities. From each of these divisicns arise what are called original or capital branches, from which smaller branches and ramifications proceed. The capital branches from the aorta ascendens are—arteriæ subclaviæ, the subclavian arteries, which run under the clavicle, or collar-bone. The carotids go from the arch of the aorta directly to the head.—The arteriæ coronariæ of the heart, are so called because they form a sort of crown on the basis of the heart. The principal subordinate branches from these are from the subclavian arteries, the mammaria interna, the mediastana, the pericardia, the diaphragmatica minor sine superior, thymica, trachealis, vertebrales, cervicales, and intercastales, and the axillary artillary, which is only a continuance of the subclavian from where it goes out of the thorax to the axilla. The carotids are divided into external and internal; the external sends out the maxillaris interna, occipitalis, temporalis, lingualis, &c. The internal sends out the opthalmic and middle cerebral arteries.

The capital branches from the aorta descendens are—in the breast, the bronchial, œsophageal, intercostal, and inferior diaphragmatic; within the abdomen, the cæliac, which divides into the hepatic, the coronaria ventriculi, and the spenic; the mesenteric superior and inferior, the emulgents, the spermatics, the lumbar arteries, &c. At the bifurcation the aorta divides into the iliacs, which are divided into external and internal. The external gives off the epigastric, femoral, tibial, &c.; the internal sends forth the sacral, gluteal, ischiatic, &c.

Arthron; any series of bones in the animal structure.

Artificial Day; the period which elapses between the rising and setting of the sun.

Artillery signifies all sorts of great guns or cannon, mortars, howitzers, petards, &c., together with all the apparatus and stores thereto belonging, which are taken into the field, and used for besieging and defending fortified places. It signifies also the science of artillery or gunnery, which, originally, was not separated from military engineering. The class of arms called *artillery* has always been the subject of scientific calculation, more than any other species, as the Italian word *arte*, in its name seems to indicate. The same name is also given to the troops by whom these arms are served, the men being in fact, subsidiary to the instruments. The other portions of an army, are *armed men*, while the artillery consists of *manned arms*. Wooden artillery appears at first view but little fitted for actual service, and yet it appears that it was used effectually in one of Auring-

zebe's campaigns in the Deccan. The commandant of a large town was nearly unprovided with cannon, having only one or two defective pieces. The town was, however, a great mart for timber. The governor securing both the timber and the carpenters, garnished his ramparts with wooden imitations or cannon; and being fully supplied with most other requisites when the imperial aimy arrived, put a good face on the business. He did more too, for he kept the secret within his own walls; and the enemy respecting the number of his train, commenced their approaches in due form, affording him thus abundance of leisure to mature his plan of defence. Every piece as soon as fired, became of course unserviceable, but he immediately replaced it by a new one. The balls from the imperial batteries were returned with the utmost facility, as, however ponderous these were, our hero was able to supply pieces of any calibre, and sent recochet shot, *selon les regles*, even with more effect than his enemy. The labours of the Carron Foundry never produced more guns in a year, than this man's ingenuity did in one siege. The enemy tired out at last, with the obstinate defence which he made from his batteries, determined to carry the place by escalade in open day. Having failed, however, in some similar enterprises, a neighbouring saint was procured, who was to head the attack, and by the sanctity of his character, to inspire the soldiers with greater zeal in a desperate cause. The holy man was raised on a platform, and carried in the rear of the forlorn hope. The governor's good luck still adhered to him. A shot from a wooden gun, when the escaladers were nearly close to the walls, overthrew the saint, and the siege was raised.

Arthrocace, in *Surgery*, is a disease of the joints, or the extremities of bones, more commonly named Spina Ventosa. When this disorder affects children, it is called Pædarthrocace.

Arthrodia, is a species of articulation, admitting of a very small degree of motion; as each bone composing the joint must have nearly a plain surface. Such is the articulation of the humerus with the scapula.

Arthrodynia, in *Surgery*, is a chronical rheumatic affection of the joints.

Arthropuosis, is a suppuration of the joints, or at least a strong tendency to form pus. In this case there is a deep-seated inflammation, obtusely painful, sometimes throbbing, and accompanied with febrile symptoms.

Arthrosis, a juncture of two bones designed for motion; called also articulation, which see,

Articulation, in *Anatomy*, the juncture or connection of two bones. Articulation is technically divided into diarthrosis, or moveable, articulation; synarthrosis, or immoveable; and amphiarthrosis, which is defined to be a compound of both the others. The immoveable connections of bones are said to be by symphysis, harmonia, suture, gomphosis, scindelesis, synchondrosis, synenrosis, or syndemosis, and syssarcosis. The moveable articulations, which alone appear to deserve that term, are divided into enarthrosis, ginglymus, and arthrodia. When the spherical head of one bone is received into a corresponding cavity of another, a joint is formed, which admits of motion in every direction, this is, what is termed enarthrosis, or more plainly a ball and socket joint, of which we gave an example in the article Anatomy, p. 80.

Artificers, those who work with the hands, and manufacture any kind of commodity in iron, brass, wood, &c., also called handicrafts and mechanics.

Artificial Lines, on a sector or scale, are certain lines so contrived, as to represent the logarithmic sines and tangents; which, by the help of the line of numbers, will solve all questions in trigonometry, navigation, &c., with tolerable exactness.

Artimourantico. While we now write, a metallic preparation under this name has received the sanction of the Bolognese Academy, and is manufacturing on a large scale for exportation from Italy. In appearance it resembles gold of 18 carats purity. It is an alloy of tin, sulphur, bismuth, and copper.

Artomeli, a kind of cataplasm prepared of bread and honey, applied chiefly to the præcordia.

Arts, *Fine*. We propose under this head to furnish our readers with a connected view of the progress of painting and sculpture in this country; and to render this really useful to the student and amateur, it will be advisable to trace somewhat of their early history in connection with their cultivation in Greece and Rome. Some have doubted whether sculpture or painting should have the priority in point of historical invention; but a moment's consideration will serve to show that the first rude efforts of the artist would be directed to a selection of the block of stone nearest in point of form to the object to be represented, and as such that it would be easier to become an artist in those materials than on a flat surface where both *outline* and *relief* would be required.

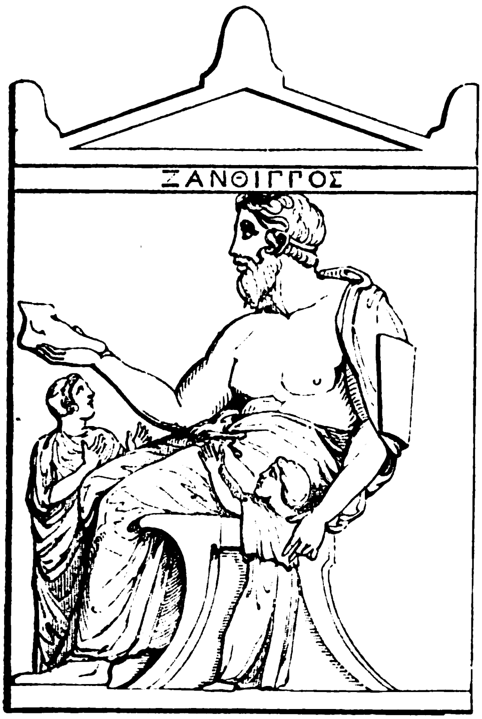
Dædalus, the first artist who acquired sufficient celebrity to have his name handed down to posterity, is said to have flourished three generations before the Trojan war; and according to the most generally received chronology, about fourteen hundred years before the Christian era. His principal and best authenticated works were large statues in wood, some of which remained until the general destruction of art under the later Roman emperors; and in spite of the rudeness of their forms, struck an intelligent traveller of the period with the grandeur and dignity of their air and character.

The spoils of the defeated armies of Xerxes in Greece, a tenth of which by immemorial custom belonged to the gods, afforded means of ample employment to the great sculptors who succeeded, among whom we find the names of Phidias, Alcamenes, Critias, Thestocles, Agoracritus, and Hegias; who were soon followed by Algelades, Callo, Polycletus, Phradmo, Gorgias, Laco, Myro, Pythagoras, Scopas, and Perelius.

Of Phidias' general style of composition, the friezes and metopes of the temple of Minerva at Athens, published by Mr. Stuart, and since brought to England, may afford us competent information; but as these are merely architectural sculptures executed from his designs and under his directions, probably by workmen scarcely ranked among artists, and meant to be seen at the height of more than forty feet from the eye, they can throw but little light upon the more important details of his art. From the degree and mode of relief in the friezes they appear to have been intended to produce an effect like that of the simplest kind of monochromatic painting, when seen from their proper point of sight; which effect must have been extremely light and elegant. The relief in the metopes is much higher, so as to

exhibit the figures nearly complete; and the details are more accurately and elaborately made out: but they are so different in their degrees of merit, as to be evidently the works of many different persons; some of whom would not have been entitled to the rank of artists in a much less cultivated and fastidious age.

A very good illustration of early basso-relievo is furnished in the architectural ornaments of the tomb of Xanthippus, father of Pericles. In this, and indeed in all the early bas-reliefs, the draperies are thin, and the folds small and distinctly formed.



One of the peculiarities of the early artists was a desire to produce powerful and striking effects by gigantic figures, and this was peculiarly displayed in the animal kingdom. The practice of placing colossal lions of stone at the entrance of a temple was both an Egyptian and Hindoo usage. Abdallatif describes two that he saw at Memphis, opposite to one another, and of proportions far beyond those of nature. He says the sight of them inspired fear, for the sculptor had maintained with perfect skill all the exactness of form and proportion. These lions, he tells us, were afterwards broken and covered with earth.

It was sometimes the practice of the Egyptians to paint their colossal statues, as we learn from Abdallatif's account of the great colossus which he saw in the ruins of Memphis. Traces of red paint are still discernible on the face of the great sphynx, and on one of the four colossal figures attached to the front of the temple of Ipsambul. Among the Greeks we find colossal statues not uncommon, and several which Pausanius mentions were 30 feet high and upwards. The people of Elis set up a bronze statue of Jupiter, 27 Greek feet high, in the Altis or sacred grove near Olympia, and the chryselephantine statue of the same deity, placed in his temple on the banks of the Apheus, was probably not less than 60 feet high. Among the Greeks the most common colossal statue was the chryselephantine, though occasionally marble, and still more frequently metal, was used for the same purpose; but as it is simply our object to show how widely this taste for colossal figures was spread, it may be enough for us to cite the celebrated work of Chares (the colossus of the sun), which was set up at Rhodes. This work of Grecian art surpassed any thing that the world has ever seen.—"It was 70 cubits high (105 Roman feet). After standing fifty-six years, it was thrown down by an earthquake, but it is still a wonder even in its prostrate condition. Few men can embrace its thumb; and its fingers are larger than most statues. Huge caverns are seen in the fractured limbs, and within them immense stones which had been put there for the purpose of keeping it steady. This enormous statue is said to have cost 300 talents, and twelve years' labour." The colossus which Nebuchadnezzar set up in the plain of Dura, was "an image of gold, whose height was threescore cubits, and the breadth thereof six cubits." Herodotus also mentions a colossal statue twelve cubits high and of solid gold.

It would be a waste of our readers' time to multiply specimens, but an instance of Greek sculpture at a later period may not be out of place.

As examples of masculine beauty and majestic dignity, the greater portion of the numerous antique statues of Minerva stand unrivalled. The accompanying illustration is a representation of one which possesses these characteristics in an eminent degree, and which is now in the Capitoline Museum at Rome.

The attitude is noble and grand; and the general effect of the whole figure is greatly heightened by the simplicity and elegance of the drapery in which it is clothed.

After this introductory view of the early history of sculpture, we may at once proceed to our illustrations of British art.

The art of sculpture was imported by our Roman conquerors into Britain at a very early period. The remains of Roman and British art in England are well imagined, but executed with so little skill as to admit the conjecture, that the gods and altars, as well as the roads of the time, were executed by the soldiers. The warlike invaders left something like

the love of art behind them when Ætius withdrew his last legion. A brazen statue of king Lud was erected on Ludgate Hill. But the colossal dimensions, and fierce countenance which Bede celebrates, are bad symptoms of the power of the sculptor's art. Amplitude had been taken for sublimity, and gigantic ferocity for heroic grandeur.

The Saxons succeeded the Romans, and whatever they did had a dash of the wildness of that blunt people. Their attempts to imitate the human form are savage and hideous. But riches and repose began to aid them in softening down the barbarous rudeness of imitation; and in their sacred architecture they had begun to display some taste, when their progress was arrested by the Normans, a people as fierce as themselves. To this band of conquering adventurers we owe, among other benefits, the introduction of a better kind of sculpture. The tombs of the days of William the Norman and his sons were good examples of the Gothic taste; and the forms sculptured upon them were stiff but natural, and intelligible though coarse.

Of the state of the fine arts in France during the middle ages, but little is correctly known, but the following beautiful specimen of sculpture, forming the capital of a column executed in the eighth century, evinces considerable skill in the general outline of the figures, as well as in the execution of the drapery.

We introduce this illustration in the present historical view of our own sculpture, as it exactly resembles that which was employed in English ecclesiastical edifices in England about half a century later.

As we pass along the stream of time, the beauty of church architecture increases; and the devout meaning and skilful execution of its accompanying sculptures became more and more remarkable. The return of the Crusaders brought a taste for the Grecian art, which was then visible wherever they had marched. The church became strong, rich, ambitious, and desirous of splendour. Magnificent abbeys were built, and the whole skill and genius of the land were employed in embellishing them with traditions of the saints and legends of the church. In the days of the third Henry, the desire to excel seemed universal, and many works of true genius adorned our cathedrals. For several centuries our demands for sculpture were mostly supplied by foreign hands; and often from a foreign market. The heathen gods, under the protection of modern names, had gained a footing in the island; and a crowd of allegorical creatures came after them. If we examine our cathedrals, where plainness and simplicity should preside, there this marble offspring of affection and idle learning are seated. It is painful to hear sculpture speaking over English dust with an alien tongue. The artists of those days did, however, undertake sometimes to represent nature; but they gave only the lifeless image, they missed the serenity of slumber, and carved the horror of death. If we pass on to a later period, it will be found that the sculpture of the last hundred years has partaken more largely of English feeling and intellect; and, though often deformed by allegory and affectation, debased sometimes by vulgarity and in general unelevated and monotonous, it contains works of a high and pure order. Of some of her domestic monuments in particular England may be justly proud; here the soundness of heart has happily prompted many daring acts of rebellion against the false tendency of professional taste.

Cibber was among the first of our artists who returned to sense and nature, and his statues of raving and melancholy madness, are the earliest of our works after the reformation, which show an original grasp of mind. The cold insult of Pope is forgotten as we look on those "brainless brothers," who yet stand foremost in conception and second in execution among all the productions of English sculpture.

Rysbrach succeeded Cibber, and Sheemaker came and divided with him the public patronage. Though feeble, literal, and languid, they maintained something of the elevation of style which Cibber introduced; produced several recumbent figures which seem nature transcribed rather than nature exalted by art, yet they are nature still, and welcome from that novelty. They were heavy and ungraceful; they had not the skill to use allegory so as to make it understood, or nature so as to render it attractive.

Roubiliac's name still stands deservedly high though it is at this period suffering under something like an eclipse. His ideas are frequently just and natural, and his execution is always careful and delicate. But he sacrificed nature and simplicity for the sake of effect; his works are all too lively and too active. He has little sedate beauty, little tranquil thought. Violent passion can be carved by a commoner hand then men imagine. A broad mark is easily hit: but quiet agony of mind and deep thought are less palpable things that demand the hand of a master. Roubiliac dealt largely in abstract ideas, nor did he use them wisely. We may take his monument of Mrs. Nightingale as an example; it is his most celebrated work, and a work of beauty and pathos—a dying wife and an agonized husband. So far all is natural and consistent. But he could not be satisfied with nature and with simple emotion. He opens an iron door, and sends forth a skeleton; a Death projecting his allegorical dart against the woman, while the man seeks to stay it with a hand of flesh and blood. Can any thing be more absurd than this strange mixture of shadow and substance? See with what discretion Milton has escaped from the dfficulty of describing Death, and yet we feel satisfied with the indistinct image which he gives :—

"What seemed his head
The likeness of a kingly crown had on."

We have no grinning jaws nor marrowless bones here. When blood was first shed on earth, the same great poet makes Death rejoice as a bird of prey smelling coming carnage:

"So scented the grim Feature, and upturn'd
His nostrils huge into the dusky air."

The poet saw the difficulty; ordinary minds see

none; and hence the sculptor has given us an image which startles and disgusts.

Bacon infused more English sense into sculpture than any of his predecessors. Amidst his personifications of cities and countries, and virtues and qualities, and his crowd of chubby boys, large about the middle and long in the wing, there frequently appeared something of a better nature; his happier judgment seemed often on the point of vanquishing allegory, but the dark abstraction always prevailed. Forms which came without the pain of study or the labour of meditation, were made too welcome; he was ambitious of finding a new labour for Hercules, and a christian employment for Minerva.

Bacon's statue of Samuel Johnson is an excellent work: stern, severe, full of surly thought and conscious power: and his Howard has the look of the philanthropist. The limbs, arms and necks of both are naked; but the sentiment overcomes historical inaccuracy.

The bust sculpture of Nollekens is deservedl esteemed. This popular branch of the art, when confined to legislators, warriors, orators, and poets, becomes the handmaid of history; but the calls of vanity bring a thousand heads to the sculptor's chisel, which have no other claim to distinction than what money purchases, while a man of genius contents himself with the fame of his productions, and is either too poor or too careless to confer a marble image of his person to posterity. Nollekens, like Bankes, had the ambition to introduce a purer and more tasteful style of art. His busts, which he considered as the mere small change that enabled him to buy his marble and pay his men, will alone preserve his name.

In Flaxman's mind the wish to work in the classic style of Greece, and the love to work in the original spirit of England, long held an equal war, sometimes forming natural and beautiful unions, and often keeping purely and elegantly asunder. To the aid of his art he brought a loftier and more poetical mind than any of our preceding sculptors; and learning unites with good sense and natural genius in all the works which came from his hand. He has penetrated with a far deeper sense of the majesty of Homer, into the Iliad and Odyssey, than Canova, who dedicated his whole life to the renovation of the antique; nor has he failed to catch the peculiar inspiration of whatever poet his fancy selected for illustration. We feel that he has rarely failed to reflect a true general image of the great original; we see the same grave majesty and the same simplicity, and we own the group at once as the offspring of the spirit of Homer, Æschylus, or Dante. These works have spread the fame of Flaxman far and wide. On the bulk of his works in marble he has impressed the same serene and simple spirit: he always thinks justly, his conceptions are all inspired by strong sense and by the severer part of poetic feeling.

Westmacott has shared largely in public and in private favour, and some of the most expensive of our monuments have been confided to his talents. He has in so far profitted by the wise example of West and the good sense of Flaxman, obeyed the admonition of our cold climate, and respected the blushes of our ladies, and clothed some of his works in the costume of the country. In his Hindoo Girl there is a certain wildness of eye; the stamp of a remote land is upon her: and in his Widowed Mother and Child he has attained the pathos of truth.

The renovation of the statue of Achilles in honour of Wellington and Waterloo surpasses all imaginable absurdity. By what perversity of fancy the cast of an antique figure was thought a fit visible record of English glory, it is impossible to say. The statue of Achilles (if Achilles it be) had already told its story to the world, and it was a strange piece of folly on the part of Mr. Westmacott to press it into the British service; but in our service it cannot abide; remove the inscription, and the Greek is a Greek again. We hardly blame Westmacott for this; it is honourable enough to make money in an honest way, and we are obliged to the hand which extends our acquaintance among works of genius. But who would dedicate a translation of the Iliad as a national trophy to the honour of the heroes of Waterloo?

England may justly be proud of Chantrey; his works reflect back her image as a mirror; he has formed his taste on no style but that of nature, and no works of any age or country but his own can claim back any inspiration which they have lent him. He calls up no shapes from antiquity: he gives us no established visions of the past: the beauty and the manliness which live and move around him are his materials, and he embodies them for the gratification of posterity. He seems to work as if he were unconscious of any other rival but nature. The antique is before him, but he prefers flesh and blood, and it would certainly cost him far more labour to imitate the work of another school, than to create an image from the impulse of his own feeling. Robert Burns said, that the muse of his country found him as Elijah did Elisha, at the plough, and threw her inspiring mantle over him; and the same may be said of Chantrey: it was in a secluded place, a nameless spot, into which art had never penetrated, that the inspiration of sculpture fell upon him.

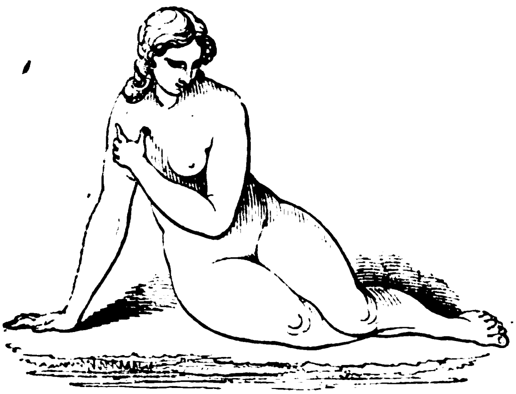
The Greeks charmed the whole earth by working exactly in the same spirit as this great man. But the liberties which they took with their Olympus gave them an advantage over modern sculptors. A Christian artist allows not his fancy to invade the sanctities of heaven—he presumes not to embody its shapes—he dares not define the presence of his Creator. Mr. Chantrey's groups, though the most admired, are not perhaps the happiest of his works.

Of all Mr. Chantrey's busts, perhaps that of the late Sir Walter Scott is the best. The poet possesses a face as changeable and various as the characters he drew in his works, and an expression which nothing but genius something akin to his own can hope to seize. In this remarkable bust the brow is full of thought, the eyes look through the spectator, and there is a grave humour about the mouth which seems ready to escape in speech. The whole face is finished with the most fascinating skill.

We may here observe, that this beautiful bust has been the parent of nearly all those which have appeared about the streets of the metropolis since the death of the above distinguished individual. Chantrey charged two guineas for the plaster cast—the Italians who have moulded it from the original charge half-a-crown.

Bailey studied under Flaxman. His conceptions are in general just, and his workmanship almost always good. His Eve is loveliness personified, and though undraped, yet breathes the purest spirit of chastity. Simple description indeed can hardly do justice to the peculiar beauty, simplicity, and modesty

of this figure, and we find it necessary to call in the aid of our artist's pencil for the purpose of illustrating the work of this highly-talented sculptor.



Of this statute we cannot speak too highly. There is a grace and almost infantine simplicity in the figure which serves to place it in the highest order of sculpture. It is now in the possession of the Bristol Literary and Scientific Institution. Mr. Lough has highly distinguished himself by a variety of figures, which are now exhibiting in his own gallery, and his best group is a masterly representation of Duncan's Horses, which Shakspeare describes as devouring each other, forming one of the portents of the death of their royal master.

Of Mr. Thom, the Scottish sculptor, we had reason to expect much, but since the completion of his figures illustrative of Burns, his career has not at all realized his early promise.

In the present enumeration of sculptors, we must not omit to notice one who has peculiarly distinguished himself by the useful application of his art to the purposes of architecture. Mr. Bubb has established a depôt in Grafton Street, East, in which a material called Lithargelite, is modelled, and converted into figures much superior in point of durability to many sorts of marble. There are more than fifty statues executed by this artist in the Regent's Park, and, amongst other works, we may particularly notice a basso-relievo, about one hundred feet long, for the Italian Opera House. His monument to the memory of Pitt has long been deservedly admired.

In concluding our historical view of modern sculpture, we cannot but turn for a passing glance to Italy. Once leaders in arts, as well as in arms, the Italians are now sadly degenerated, and they have lately lost one who seemed to bid fair to restore to them much of their ancient fame.

Of modern sculptors out of our own country, Canova certainly held the most distinguished rank, and to him we shall therefore more particularly call the reader's attention. Of the early career of this distinguished artist, whose works we shall now have occasion to notice, it may not be amiss to furnish an illustrative anecdote. Canova—like our own children of genius, Lough and Thom—was of humble extraction. He was born in a mud-walled cottage in the little village of Possagno, among the Venetian hills, on the first day of November, in the year 1757. His father died when he was three years old; his mother married again in a few months, and left her son to the charity of his paternal grandfather, Pasino Canova. Antonio was weak in person, and feeble in constitution: this but endeared him the more to his grandmother, Catterina Cecatto, who nursed him with the tenderest care, and sung him ballads of his native hills, infusing a love of poetry into his heart, of which he ever afterwards acknowledged the value. In his tenth year he began to cut stone, and it was his grandfather's wish that he should succeed him as hereditary mason of the village. The weakness of his body and his extreme youth were ill suited for a laborious trade. Old Pasino, who was a man of some intellect, indulged him in modelling of flowers; and in drawing of animals. Such was his success, that, in his twelfth year, he obtained the notice of the noble family of the Falieri, who had a palace in the neighbourhood. As the notice of the great can rarely be purchased but by something like a miracle, a species of miracle is told to account for the good fortune and fame of Canova. A great feast was given by the Falieri, the dinner was set forth, and the guests assembled, when the domestics discovered that a crowning ornament was wanting to complete the beauty of the dessert, and old Pasino tried in vain to invent something suitable. Young Antonio called for butter, and instantly modelled a lion with such skill and effect as excited the astonishment of the guests—the artist was called in, and he came blushing to receive the caresses of the company, and the first applauses of that kind and opulent family. Its head had the sense to see Canova's genius, and the generosity to encourage him. From that moment his fortune was made, and we speedily find him distinguished by the patronage of the great and powerful of his native land.

The first illustration in our plate Arts, *five*, represents a group from the monument to the memory of the Archduchess Christine, of Austria. This beautiful and pathetic composition was executed by Canova, at the desire of her husband.

There are nine figures employed in the entire monument, and we select for our first group the principal series of three figures.

The figures are all of the natural size, and consist of an allegorical figure of Virtue, with two young females bearing torches: Virtue is represented in the form of a young matron of a dignified but melancholy aspect, bearing before her the funeral urn, on which she seems to rest her forehead; she is attired in a rich tunic, and her hair is unbound and spread in a disorderly way over her shoulders. Ascending the steps, which are spread with a rich carpet, she approaches the door of a tomb. The attendant who goes before her has already reached the entrance, where her steps seem for a moment arrested by the awful feelings which the place inspires, but, bending forward, and lowering her torch to illumine the dark abode, she prepares to enter. The other attendant, who is behind, and is seen in profile, has the same simplicity of dress and character; with downcast eyes, and slow and devoted step she follows her celestial conductor: two wreaths of flowers, joined at the top of the urn, serve to connect the two foremost figures, which would separately form a perfect and charming composition.

Our second series from Canova is selected from a basso-relievo, representing Hercules destroying his children with arrows. It is usually known by the name of the "Infuriate," and we cannot do better

ARTS. FINE.

ITALIAN SCULPTURE. – CANOVA.

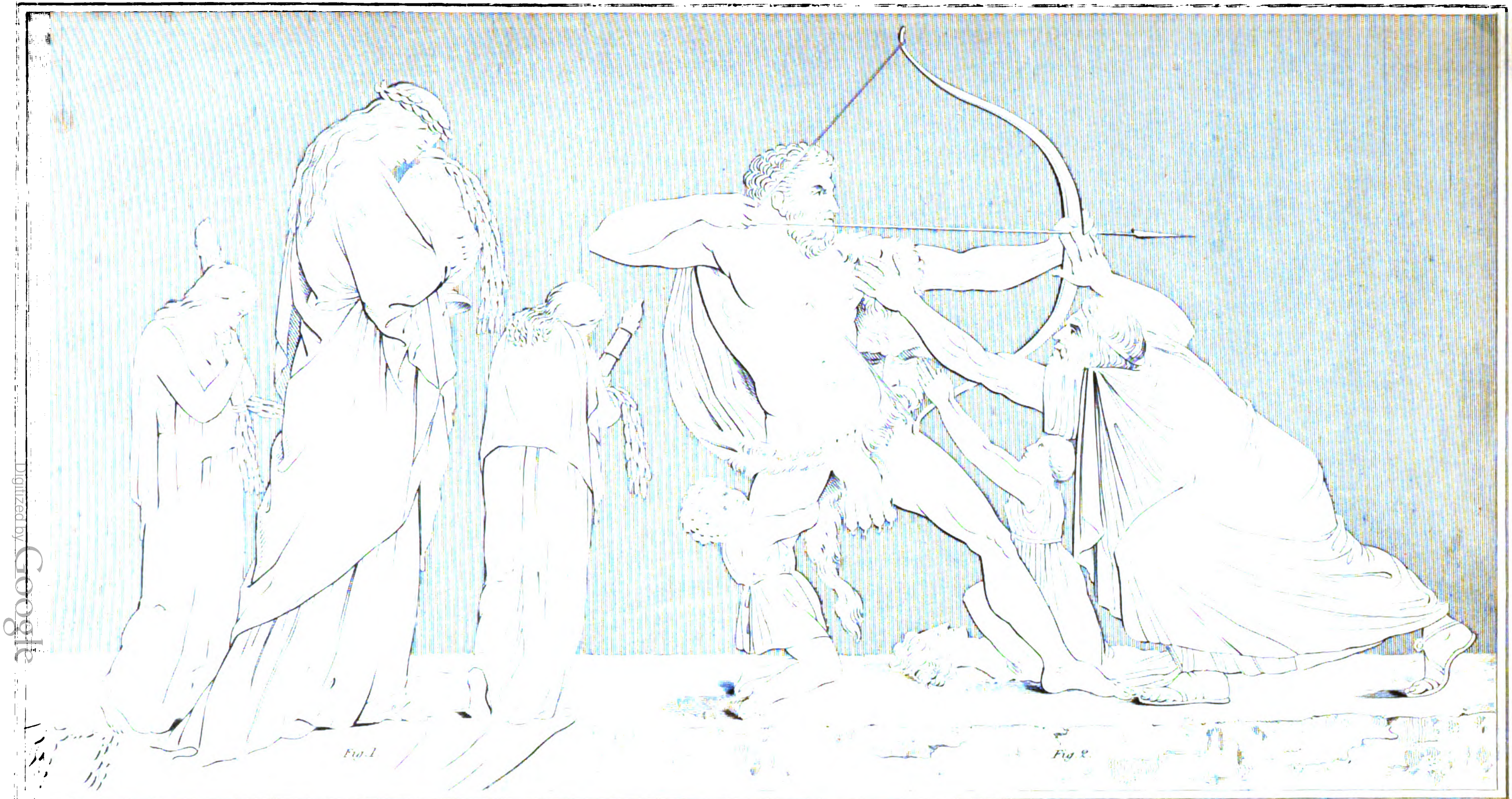


Fig. 1   Fig. 2

London, Published by William Orr, Paternoster Row, Sept.r 29. 1832.

than take the description of the entire work from the pen of the Countess Albrizza, which will enable our readers fully to understand the arrangement of the figures we have selected. (See FINE ARTS, *plate* 1, *fig*. 2.

"The son of Jupiter and Alcmena, after having triumphed over the perils to which the hatred of Juno had exposed him, returned to the bosom of his family, where he found that Lycus, the Theban exile, had forcibly taken possession of his throne, and meditated the destruction of his race. Him the hero slew; but while in the act of purifying himself from the stain of blood, by sacrificing in the temple of Jupiter, the malignant goddess, still pursuing him, caused him to be seized by a sudden frenzy, during which, he destroys his own offspring, believing them to belong to his enemy Euristheus. Canova has pourtrayed this tragical subject with great power and judgment: an altar smoking with the sacrifice, and a pedestal supporting the statue of Jupiter, occupy the centre of the basso-relievo; already the pavement is strewed by the bodies of his children transfixed by arrows, and lying in various attitudes of death. Hercules, still pursuing the work of destruction, is in the act of directing a deadly shaft against one of his infant children whom its unhappy mother has caught up in her arms, and tries to shield with her own body; extending at the same time her hand and arm towards her infuriate husband, with a look of the deepest distraction and moving supplication: she seems to exclaim—'Have pity on thine offspring, thy wife, or thyself;' but in vain,—his insensibility to this appeal, even more than the slaughter which surrounds him, proves the dreadful delusion under which he labours. One child has taken shelter behind its mother, and hiding its face in her vest, seems to think itself secure from the danger which it does not see. Another hides itself behind the altar, and raises its little hand to its ears to deaden the horrid shrieks which fill the temple. A third has seized his father's knee, and, although ignorant of his fault, tries by his piteous cries to stop his fury. A young female is on her knees before him, her hands raised in vehement supplication; and the aged Amphitryon, rushing forward with all the force which age has left him, and neglecting his own safety, places one hand on the breast of Hercules, and endeavours with the other to arrest the murderous shaft.

"Clothed only in his lion's skin, the large and immensely powerful frame of the hero are finely displayed, and fully correspond with the fame of his matchless force; while his distorted features and infuriated aspect show that his mind is darkened by some dire delusion. The relentless goddess, however, unsated even by this slaughter, prepares for herself the deeper vengeance, when, the light of returning reason, shall awaken that terrible and insupportable remorse under which the most wicked of mankind may excite the pity of men and the clemency of Heaven."

This account from the pen of an Italian lady of rank, and high literary acquirements, well describes the powerful conception of Canova, in the work represented in our plate. We have taken the principal figures of the group, the arrangements of the rest will readily be understood.

The Religion of Canova may be said to rank amongst the finest of his works. We shall not here enter into a discussion of the fitness of sculpture for illustrating the highest and holiest of feelings of the human mind, but it is an undoubted fact, and one to which we have alluded elsewhere, that art owes more to the patronage of the clergy than the laity. It was so in ancient Greece and Rome, and is so in the present day.

The splendid statue now before us, which is about twenty-five feet in height, is a sufficient example of what religious enthusiasm will effect when grafted on a high degree of cultivation. On the head of the figure is a tiara, bearing in its front the symbol of the Trinity. The one hand is raised to heaven, while the other rests upon a medallion, on which is sculptured the head of the apostle Peter. We can say but little in praise of this latter portion of the work. The style is purely French. There is a prettiness about it which is but little in accordance with the simple dignity of the principal figure. This fine statue was executed for a temple he proposed to erect at his own birth-place. The previous remark also applies to some of his dancing girls: they are rather the figurante of the French opera, than natural models of classic beauty.

We come now to the *Art of Painting*, and purpose tracing its progress in the same way as we have done its progenitor Sculpture.

We are doubtless indebted to the Greeks for the high state of cultivation which the imitative arts have acquired. In sculpture they attained so high a pitch of excellence, as to remain unrivalled even to the present moment; and it is probable, that as far as relates to the perfect imitation of a single figure, in taste, in expression, and in execution, the same may be said of their painting: but there is much reason to conclude, that in many branches of that art they are surpassed by many artists in the present day.

The practice of the fine arts, so far as it extended to the delineation of certain figures, is of the highest antiquity in Egypt; and, indeed, both the enchorial and sacred writings anciently used in that country, have been supposed to have only changed their forms from actual drawings of visible objects, to those of rude sketches of the same figures, and finally into a running written character, in which the original features were entirely lost. In those papyrus rolls, which are frequently to be found in the coffins of mummies, all these different species of characters are generally employed; and the following group has been reduced from an original fragment of one of those rolls, as affording a perfect idea of the peculiar style of ancient Egyptian art, its chief characteristics being firm decided strokes, simplicity of outline, and only a general indication of the principal features of the object delineated. It will, perhaps, be interesting to mention, that the annexed group probably represents Isis, with her horned head, standing in one of those boats in which the ancient Egyptians supposed the planetary bodies to perform their courses. The accuracy of the original drawing may be relied on, as the roll is in the possession of the Editor.

But in Egypt, the artists appeared to possess no power of selection. When a specific form of character was once adopted, there it remained, and was repeated unchanged for generations. Little action was given to figures, and no attempt at all at expression. Pliny says, that the statues made by the Egyptians in his time, differed in no respect from those made by them 1000 years before. Of their painting, a few figures remain to us; but their date is by no means clear. Two of them, seen at Thebes, and described by Bruce, are supposed by him to be of the time of Sesostris (about 700 years B. C.), who is said to have beautified and restored that city; but this is mere conjecture. Of these paintings, he remarks, that they may be compared with good sign-paintings of his day.

Pliny also speaks of paintings at Ardea, in Italy, older than the foundation of Rome. Unfortunately we cannot follow this author precisely, in his account of the rise of the art in that country any more than in Greece. By his own statement, the only guides he had, except tradition, viz., the Greek authors, were extremely incorrect. But though we may not trust our judgments with him on the origin of painting; yet the view he offered us of its progress, the imperfection of its first essays, the gradual advance towards perfection by the addition of new and more valuable qualities, and the retrograde steps it fell into after it had reached its acme, present an order of things so precisely following the system of nature in every part, that we cannot hesitate to quote his view as given in the *Encyclopædia Britannica.*

After smiling at the claims of the Egyptians, who said that the art had been known and practised in Egypt 6000 years before it was introduced into Greece, he says, that it was not practised in Greece till after the siege of Troy; a circumstance certainly not credible, if the story which he relates of Semiramis be true; and if Homer be correct in imputing so much of sculpture as he does to the artists of that period; or the amusements of Penelope, of Andromache, and of Helen, at their looms, be at all founded in facts. It is not probable that so much of other arts, particularly of weaving coloured designs, should exist, without some advance being made at the only source whence it is natural to imagine they could arise. It is vain to discuss the point; nor is it of much consequence whether it were at Corinth or at Sicyon, that the practice of drawing first attracted particular notice. But, as M. Fuseli has beautifully observed in his first lecture, "if ever legend deserved our belief, the amorous tale of the Corinthian maid, who traced the shadow of her departing lover by the secret lamp, appeals to our sympathy to grant it."

The arts in general, and painting in particular, appear to have been practised in Etruria at a very remote period; and Winckelmann thinks it probable that the Etruscans had made considerable progress in the arts dependent on design, before their communication with Greece. The same inference may be drawn from some passages in the Roman authors, though the evidence of no Etruscan writer on art has been handed down to us. It is probably not without foundation, that the Romans have been accused of having endeavoured to destroy every vestige or monument which they found in the countries they overran, that no traces might be left of the antiquity of the neighbouring nations. This jealousy is in some degree corroborated by the silence of their writers, who appear only to have preserved the names of the vanquished people as triumphal trophies; and not for the purpose of making posterity acquainted with the state of their civilization, or the arts which they had cultivated long before Romulus and his associates came to establish themselves on the banks of the Tiber.

The accompanying vase, which forms part of those excavated by Sir William Hamilton, may be considered as one of the most perfect models of symmetrical outline from the Etruscan school.

Pliny admits, that at Cære, in Etruria, and at

Ardea and Lanuvium, in Latium, there existed in his time some paintings which attracted the admiration of the curious, and which were more ancient than the foundation of Rome. In the third chapter of the 35th book of his *Natural History*, he thus expresses himself: "I cannot contemplate without astonishment those paintings at Cære, which appear recent and fresh after so many ages. The same may be said of the Atalanta and the Helen, which are seen in a ruined temple at Lanuvium. The artist has represented Atalanta naked, and both the figures are of exquisite beauty."

It had long been regretted that the ravages of time and the devastation of Italy had deprived us of every vestige of the paintings of the Etruscans, when the Padre Paciandi, a Theatine monk, discovered near the ancient Tarquinia, formerly belonging to Etruria, several tombs decorated with paintings. He communicated this interesting discovery to the Count de Caylus, in a letter from Rome in 1760, in which he informed him that in the environs of Tarquinia are found a great number of small grots, which had served as tombs, and which were decorated with paintings on the pilastres and friezes.

Winckelmann also speaks of the paintings found in the tombs near Tarquinia; many of the friezes represent combats and assassinations, others appear to relate to the doctrine of the Etruscans on the state of the soul after death.

From the few remains of Etruscan painting which have escaped destruction, it may be inferred that in Etruria, as in every other country, the art was nearly in the same state of rudeness in its infancy; and that at a more advanced epoch, when it began to assume a national feature, it was marked with a similar character to that which was preserved in Tuscany after the revival of the art; that it was more distinguished by grandeur than beauty, and by energy than grace. That this was really the fact, will we think be readily admitted by any person capable of appreciating the accompanying graphic delineation, which for force of expression and poetry of motion is infinitely superior to many designs of the present period.

It was on a vase formerly in the possession of Mr. Hope.

The splendid models of antiquity which are still extant, have left no doubt of the perfection which the art of sculpture had attained, but the more perishable quality of pictures has prevented any direct evidence reaching us with respect to the powers of the Greek artists in painting. We collect from the work on painting of Pliny the elder (which was in a great measure compiled from treatises existing in his time, and from his personal knowledge), that that art had attained an excellence which equalled that of sculpture, and many eminent masters of both are enumerated by him. Phidias, renowned as a sculptor, was also a painter, Apollodorus of Athens is noticed by Pliny as being the first whose painting fixed and absorbed the attention of the spectator, and who discriminated with delicacy the various gradations of shadow in painting, and hence obtained the name of the *shade painter*. Parrhasius, who flourished about the same time, contributed to the advancement of the art by the attention which he paid to the symmetry of the human figure, giving improved expression to the countenance, and carefully finishing the extremities. The greatest painter, however, of ancient times was Zeuxis; whose most celebrated work was the picture of Venus at Crotona, said to have been executed from a selection of five of the fairest virgins of that city. To these must be added, Aristides, Pamphilus of Macedon, Protogenes, and Apelles, who was the painter of Alexander the Great.

The opinions expressed by contemporary authors as to the excellence of these painters, must necessarily be but relative, and can furnish no criterion for a comparison of their performances with the works of modern artists. Much learned controversy has been employed as to the merits and demerits of ancient painting, yet with very few grounds on either side on which to found any arguments. Although not possessed of any paintings of the great Greek masters, surely it may be reasonably inferred that those who had attained such excellence in sculpture, who had discovered the secret of imparting such grace, such nature, such dignity to their statues, and who equally cultivated and admired painting, must also have attained a considerable eminence in that art; their excellence in sculpture may be fairly taken as a key to their standard of taste, with regard to painting. On the other hand, however, it must be confessed that in all probability, they laboured under the great disadvantage, which would necessarily arise from a want of that knowledge of colours, with which chemistry has furnished the modern artist. In addition to this, it can scarcely be doubted that they were ignorant of the practice of painting in oil, although Sir Joshua Reynolds is rather disposed to adopt a contrary opinion.

The only specimens from which we can form any decisive judgment, are the remains which were discovered in Herculaneum and Pompeii, and the frescos or paintings in the baths of Titus. Of the latter it may be observed as a proof of their merit and excellence, that on their discovery, some of them were attributed to Raphael. Although these paintings are unequal to the productions of modern art, both in their colouring and effect, yet some of them are undoubtly of the very first merit in design. But it must be remembered, that they were the work of an age when the arts were already declining; and they cannot be in any degree considered as exhibiting a type of the meridian splendour of the Grecian masters.

Of the paintings found at Pompeii and Herculaneum, it is sufficient to observe that these were small and unimportant country towns, and consequently not likely to possess even what might be regarded as specimens of the best state of the art of the period at which they were executed.

There is every reason to suppose from the minute descriptions of Pliny, Pausanias, and Quintillian, that in the essential parts of invention, expression, grace, and character, the painters of Greece and Rome, rivalled the sculptors; but in the modern invention of grouping, and the union and separation of groups, in the accompaniments of perspective, in beauty of landscape and back ground, and in extreme refinement of colouring, it is probable they were deficient. On these points the descriptions which remain afford no grounds for conclusions. The attempts at back ground in the pictures of Herculaneum are generally puerile, and the most beautiful productions of ancient painting with which we are acquainted, are figures relieved off plain grounds, or rather blended into them.

The fine arts continued to decline with the Roman power, until they were, at last, involved in one common ruin with every thing great and civilized. The history of painting, from the fifth to the eleventh century, is little more than a blank. Still the art was not quite extinct; it existed amidst the terrors of war and bigotry, cherished by the Greek monks in their silent seclusions; and for two centuries, at least, previous to the era commonly assigned to its revival, was practised, though humbly, in fresco and mosaic. With the rise of the Italian republics commences the period at which it assumed a different character; artists were summoned from Greece to adorn the public and private buildings of Florence and Pisa, and Mr. Flaxman states that the mosaic pictures in the interior of St. Mark's at Venice, which was built as early as 1085, are from Greek paintings of the same age. There is little doubt that in some parts of Italy, schools of painting were established as early as the eleventh or twelfth century.

The style of the art at this period is exemplified in the remains which exist; there are in the libraries of the Emperor of Austria and King of France, Greek paintings of great beauty, which were executed in the middle ages; but the finest specimens are to be found in the church of Santa Maria Maggiore, at Florence, which contains the Transfiguration, Resurrection, and Glorification of Christ.

Giovanni Cimabue was born at Florence in 1240, and instructed in the ordinary practice of the Greek artists of the day. But he soon outstripped his masters; and the almost divine honours which he received from his fellow-citizens for a picture of the Virgin, encouraged him to pursue the art with ardour. His pupil Giotto, to whom the world is indebted for the portraits of Dante, Brunetti, and other men of eminence of that period, contributed still further to the advancement of painting, by returning to nature as the standard by which to regulate the actions and expressions of his figures.

After the lapse of nearly one hundred years from the death of Giotto, Tomaso da San Giovanni, better known by the name of Masaccio (from his total neglect of personal appearance), exhibited a more elevated taste, and a grander style of execution than his contemporaries. The art under his hands may be said to have advanced from the weakness of infancy to the station of youth, verging towards the vigour of perfect manhood. He was the first to compose with an eye to the effect of a whole picture. He managed his groups and single figures upon the principles of perspective, which had been taught him by the sculptor Brunelleschi; and by understanding the effect of those principles, first placed the feet of upright figures truly flat upon the ground, and foreshortened his heads and figures with truth and effect. In fact, it was to him future artists were indebted for a more sure and full direction of the line in which the art ought to be pursued. He studied nature with the greatest attention, gave breadth and simplicity to his draperies; and most admirable action, character, and expression to his figures, which are justly and appropriately employed. Even Raphael did not scruple, eighty years afterwards, to study, and sometimes to adopt, his actions; of which there is an extraordinary instance in the figure of St. Paul preaching at Athens. Michael Angelo is also reported by Vasari to have regarded his pictures with great respect and attention. His principal works in the chapel of the Brancacci, in the Church del Carmine, at Florence, became the school of study for all those excellent artists who succeeded him; till at length Leonardo da Vinci, born near that city in 1445, two years after the death of Masaccio, came forth with superior lustre, and eclipsed all that had preceded. Endowed with uncommon genius, all arts and sciences seemed scarely to offer a sufficient field for the exertion of his talents. He grasped at all, and succeeded in whatever he undertook; but by his versatility wasted much of his time in experiment. Had he persevered with steadiness in pursuit of the art of painting, he probably would have carried it to the utmost perfection. As it was, whatever he painted came from his hand elevated and adorned by the pencil of the artist, and presented a complete originality of effect. To truth and precision of character, and whatever had been well done by Masaccio, Leonardo added new and most valuable qualities, by introducing the principles of chiaro-scuro, and depth of tone in colour. By the former of these, pictures were relieved from the tameness of mere imitation, and acquired an increase of power in boldness and strength of relief, and force of effect. Michael Angelo in design, Corregio in finish and chiaro-scuro, and Rubens in composition, are surely indebted to Da Vinci for the foundation of much of their excellence as artists.

A history of the ancient schools of painting is nothing more than a history of the painters who founded them. Michael Angelo and Raphael have the foremost claim to our attention; and we cannot do better than furnish our readers with the masterly contrast of these eminent painters, given by Sir Joshua Reynolds:—"If we put those great artists," says he, "in a light of comparison with each other, Raphael had more taste and fancy, Michael Angelo more genius and imagination. The one excelled in beauty, the other in energy. Michael Angelo has more of the poetical in operation; his ideas are vast and sublime; his people are a superior order of beings; there is nothing about them, nothing in the air of their actions, or their attitudes, or the style and cast of their limbs or features, that puts us in mind of their belonging to our species. Raphael's imagination is not so elevated; his figures are not so much disjointed from our own diminutive race of beings, though his ideas are chaste, noble, and of great conformity to their subjects. Michael Angelo's works have a strong, peculiar, and marked character; they seem to proceed from his own mind entirely; and that mind so rich and abundant, that he never needed, or seemed to disdain, to look abroad for foreign help.

Raphael's materials are generally borrowed, though the noble structure is his own. The excellency of this extraordinary man lay in the propriety, beauty, and majesty of his characters; his judicious contrivance of composition, correctness of drawing, purity of taste, and the skilful accommodation of other men's conceptions to his own purpose."

A taste for the fine arts appears to have been experienced in Germany early in the fifteenth century, though it made but little progress for half a century. At that time Albert Durer relieved it from little better than obscurity by his ingenuity, his fertile invention, and his skilful attention to minute imitation of individual forms. He carefully studied the human figure, but wasted his time in fanciful schemes for regulating proportion, and never attained any very high rank as an artist. The bane of his style, if it may be so called, is meagreness and poverty of forms, mean expression, and capricious and often vulgar invention. Lucas Van Leyden was the best of those who attempted to rival the name of Albert Durer, unless we except Holbein; who, though he never equalled him in composition, infinitely surpassed him in portraiture. The taste of the Germans totally changed after they possessed the knowledge of the works of Michael Angelo.

The history of the art in the neighbouring countries of Flanders and Holland, is merely the same with that of its progress in Germany, till about the middle of the sixteenth century. The extreme richness of colouring which had been effected by John Van Eyck, was maintained entire; and seems almost exclusively to have occupied the attention of the Flemish artists. Their distance from Italy, and the consequent want of intercourse with that country, precluded any precise acquaintance with the peculiar beauties of ancient art; and having no model to guide them, or rival to contend with, they were at liberty to follow the suggestions of their own inclinations. It conducted them to as precise an imitation of the effects of natural objects immediately presented to their eyes as lay in their power. The established religion here, as in Italy, found occupation for the artists in a considerable degree; but its exercise soon deviated into common life, and reached its ultimatum in the days of Rubens and Rembrandt. The former of these "meteors of the art," shining in a sphere completely his own, irradiated the world with a brilliant and uncommon lustre. Possessed of a mind as full of genius as energy, he appears without difficulty to have embraced from contemporary artists, and the great masters of Italy, whose works he visited, those elements of which he composed his own system; the principal features of which are an union of the splendours of the Venetian school, with a grandeur of outline drawn from the Florentine, without its correctness.

So very little is known of what occurred concerning the art of painting in this country, previous to the time when Henry VIII. encouraged the abilities of Holbein in portraiture, and invited Titian to come here, that it would be useless to endeavour to trace its history. Enough, however, is known to satisfy us that it was at a very low standard. It was but little before his time that the people of England began to throw off the yoke of ignorance and barbarism, and to cultivate literature and science. The ambition of Henry to be renowned, and his spirit of rivalry to his great neighbour, Francis I. of France, were quite sufficient motives to stimulate him to the proud aim of becoming a patron of the liberal arts; had not his theological discussions with Luther, and afterwards his more sublunary quarrel with the Pope, so powerfully diverted his attention from them, and produced him so active an employment in deciding the course of the reformation in religion which consequently ensued.

Charles I. endeavoured to introduce a feeling for the art, which had previously been wanting in this country; but for which he appears to have had a very great affection. He employed Rubens during his short residence here, as envoy from the king of Spain, to paint the ceiling of the banquetting room, now the chapel of Whitehall; and procured a treasure of inestimable value to the country by the countenance and encouragement he afforded to Vandyke; and also to other ingenious foreigners who have enriched the country with their productions. He formed a very considerable collection of pictures, in addition to those already possessed by the crown, and at the suggestion of Rubens bought the Cartoons; he employed an artist to copy the works of Titian in Spain, and purchased the cabinet of the Duke of Mantua, at the cost of twenty thousand pounds, and some valuable pictures were sent him as presents. The whole was sold and dispersed by the parliament in 1643, who gave especial orders "that all pictures which had the representation of the Saviour or the Virgin Mary in them, should be burnt." After the restoration many of them were returned to the royal collection, but only to meet utter annihilation by the fire which consumed the palace of Whitehall.

Of those who have practised in this branch of the art, and are departed, Reynolds, Romney, Opie, Barry, Fuseli, and Lawrance, require to be particularly mentioned. The former, with all the splendour of chiaro-scuro and colour, which no one since Rembrandt has wielded with so much power, exhibited in his pictures of Hercules strangling the Serpents, Macbeth, Cardinal Beaufort, and Ugolino, a fund of historic power. Romney also had poetic imagination, feeling, and expression; and in the little leisure allowed by his general practice of portraiture, indulged in the delights ideal subjects afforded him; while Opie presented "images new and striking, drawn directly from nature," and "what he wanted of academical or classical information, he compensated for, in a great measure, by character, by force, and by a just and bold imitation." Barry regularly educated himself for the practice of art, and undoubtedly had the highest and most enthusiastic feeling for its best qualities. With a generons zeal worthy of the highest encomium, he broke entirely from all consideration of the ordinary style of subject or design; and contemplating his art in the most elevated manner, attempted to embody the poetical ideas he entertained. His most sincere admirers must, however, regret that those excellent sentiments, which he so ably inculcated by his pen, were not more completely supported by his pencil.

We have visited the Society of Arts, which are said to contain some of his highest productions, and the reader may judge of our surprise when we beheld Dr. Burney floating in the "Triumph of the Thames," in a bag-wig and gown. Barry was too eccentric in his habits to be a wise man. He was vain, and assumed a peculiarity of feeling to excite an interest, which his merit, as a painter, would otherwise have ensured him.

The names of Fuseli and Lawrance are too fresh in our memories to excite any other than feelings of pain for their loss.

The first of these distinguished artists excelled in the sublime, though it was a species of sublimity which often approached to extravagance. There was a great similarity between Blake and Fuseli; and though the latter had more knowledge as a painter, he was equalled in poetry of conception by the amiable and fervent-minded Blake. The errors of Fuseli arose from the same energy of character which produced his greatest beauties, and this is proved by his own frequent and impassioned declaration, that he would sooner be the author of the forced and capricious style of Gottyius and Spranger, than of the in-insipid taste, to use his own phrase, of Albert Durer. Now the merits of Albert Durer have been examined in the early part of this article.

Last, though not least in the list of eminent artists who have passed from us, we must place the name of Lawrance; the greatest master of portraiture which this or any other country has known. His works form the pride and ornament of every court in Europe, and sovereigns contended for the honour of a sitting. The likenesses of Lawrance were as near to perfection as refined painting can be said to permit, and rarely did he fail to impart to his portraits the refinements of his own mind. To coin a phrase, they were *nature idealized*. In his female portraits—the great test of talent—he had infinitely more grace and variety than Vandyke, or any who preceded him; and Fuseli was often heard to declare, that his female eyes were better than those of Titian. As a curious item in art, and as an indication how his labours were appreciated by the great and powerful, it may be enough to say that he had more orders than he could execute, at prices varying from *two* to seven hundred guineas for each picture.

The art of painting in water colours springing from British soil, and fostered by native talent, ought to be viewed by our countrymen with redoubled interest, from its commencement by Sandby, during its rapid progress, to its ultimate success, aided by the brilliant powers of a Girtin, a Turner, a Prout, a Cattermole, or a Robson.

A confined sphere has been fallaciously urged against this beautiful branch of art; but the "Rembrandt in his Study," of Stephanoff, the "Ann Page and Slender," of Richter, the marine subjects of Fielding, the glowing landscapes of Robson, the picturesque magnificence of Prout, and the domestic beauties of Sharpe, prove the great range of which it is capable; and our increased knowledge of the properties and manufacture of colours affords a reasonable hope of overcoming the perishable nature of those in early use.

The first period at which we hear of water colour painting is about 1710, but the names of Chatelain, Pillement, and their contemporaries fade before the greater genius of Paul Sandby, who was born at Nottingham, in 1732. While studying in the drawing school in the Tower, at the age of fourteen, he gave such indications of future talent, that in 1748 he accompanied General Watson, as draughtsman, through the highlands of Scotland, and etchings from his sketches made during the tour, attracted much observation. The best productions of his pencil are yet rarely surpassed for spirit, clearness, and transparency.

John Cozens excelled in wild and romantic scenery, but his works are little more than tinted chiaro-scuro, and he terminated a life, of which little is known, in a state of mental derangement in 1799.

Michael Angelo Rooker, R. A., was educated as an engraver by his father, and subsequently became a pupil of Paul Sandby; his most noted works are the views painted to illustrate the series of Oxford Almanacs; and his large collection of drawings after his death, which took place March 3, 1801, brought about £1,240.

A new and brilliant era in this school, hitherto holding an uncertain and dubious rank, sprung up under the auspices of Thomas Girtin, who, when his talents for painting first developed themselves, assiduously studied nature; to his tour in Scotland, with his early patron Mr. Moore, may doubtless be attributed the wildness of imagery and general boldness which stamps with pre-eminence the finest productions of this master.

Nothing could exceed the grandeur and originality of his conception, but a want of drawing is frequently observable in many of his paintings, and he is supposed to have been tempted to work with less regard to correctness of form, in proportion to the ease with which he produced depth and richness of colour, and to have become at length so enamoured of colouring and effect, as to consider drawing of little consequence to the character of a picture.

But that vicious course which makes a wreck of the body, cannot fail to ruin the mind; the continued sensual indulgence of this extraordinary man enfeebled his mental powers, and the distinguished competitor of Turner, the thoughtless, kind-hearted Girtin, by a premature death in 1802, perhaps but saved his posthumous fame from the imputation of sinking into a mannerist.

About 1804, the conversation among many eminent artists frequently turned upon the injury their works sustained in the exhibition rooms of the Royal Academy, being often hung in bad light from insufficiency of space. The academicians were sensible of the unfitness of their rooms, for the purposes to which, from necessity alone, they were appropriated; they had no space to build on, and the evil was without remedy.

To these circumstances the Society of Painters in Water Colours owes its origin; and the first exhibition was opened in Brook Street, Grosvenor Square, to which the Royal Academicians were the foremost in crowding, and unanimous in wishing that success to the undertaking with which it has been crowned, from its first opening on the 22d of April 1804, to its present annual exhibition, in Pall Mall, East.

In concluding this article, it may be proper to state, that we have confined ourselves as closely as possible to an historical and critical view of the Fine Arts. The *practice* of painting, sculpture, engraving, modelling and casting will be found under those several heads.

Arts, *Useful*. See Manufactures and Commerce.

Arundel Oil; this name has been given to a powerful purgative medicine, extracted from a nut growing in the East Indies.

Arundelian Marbles; ancient marbles illustrative of the history and mythology of the Greeks. They are so called from the Earl of Arundel, by whom they were conveyed from Paros into England.

They contain the principal epochs in the Athenian history, from the first year of Cecrops, 1582 years B. C., to 354 years B. C.

ARUNDO; the reed or instrument which separates the threads of the warp.

ARX; the ancient name for the citadel of a fortified town.

ARYTÆNO EPIGLOTTI; fleshy fasiculæ attached to the arytænoides and the epiglottis.

ARYTÆNOIDES, in *Anatomy*, two cartilages forming the head of the larynx.

ARYTHMUS, in *Music*, the modulation of time.

AS. The Romans used this word in three different ways, viz., to denote, 1, any unit whatever, considered as divisible; 2, the unit of weight, or the pound (*libra*); 3, their most ancient coin. In the first use of the word, the pound, foot, *jugerum sextarius*, were called *as*, when contradistinguished from their divisions or fractions. In fact, the word was applied to any integer, as, inheritances, interest, houses, funds, &c. Therefore *ex asse heres* signifies *to inherit the whole*. Different names were given to different numbers of *asses: dupondius (duo pondo)* = 2 *asses, sestertius (sesqui tertius*, viz., the third half = 2½ *asses tressis* = 3 *asses, quatrussis* = 4 *asses*, and so on to *centassis* = 100 *asses*. The *as*, whatever unit it represented, was divided into 12 parts or *ounces (unciæ)*, and the different fractions of the *as* received different names, as follows:—

As	12 ounces.	Quincunx . .	5 ounces.
Deunx . . .	11 ..	Triens	4 ..
Dextans . .	10 ..	Quadrans, or teruncius .	3 ..
Dodrans . .	9 ..	Sextans . . .	2 ..
Bes, or des .	8 ..	Uncia	1 ounce.
Sextunx . .	7 ..		
Semis . . .	6 ..		

Sescuncia was 1½ ounce.

1 uncia contained 2 semiunciæ
3 duellæ
4 sicilici
6 sextulæ
24 scrupula (scriptula, or scripula,)
48 oboli
144 siliquæ.

Scholars are not agreed on the weight of a Roman pound, but it is not far from 327.1873 *grammes*, French measure. Budæus has written 9 books *De Asse et ejus Partibus* (Of the As and its Parts). In the most ancient times of Rome, the copper coin, which was called *as*, actually weighed an as, or a pound, but, in different periods of the republic and the succeeding empire, this coin was of very different values.

ASAPHATUM; a sort of serpigo, supposed to be generated in the pores like worms.

ASAPHEIS; defective utterance.

ASARITES, in the ancient pharmacopœia, implied a diuretic wine.

ASAR; a Persian gold coin, worth about six shillings.

ASBESTINUM; a cloth or paper made from the mineral called asbestus.

ASCENDANT, in *Astrology*, any heavenly body supposed to preside over the fate of an individual.

ASCENDANT; an ornament in masonry and joiner's work, which borders the three sides of doors, windows, and chimneys.

ASCENDING, in *Astronomy*, is said of such stars as are rising above the horizon in any parallel of the equator; and thus, likewise, *ascending latitude*—the latitude of a planet when going towards the north pole. *Ascending node* is that point of a planet's orbit, wherein it passes the ecliptic to proceed northward. This is otherwise called the *northern node*.

ASCENDING, in *Anatomy*, is employed to describe that part of the aorta from the point where it leaves the heart to its point of curvature.

ASCENDING VESSELS, in *Anatomy*, those tubes which carry the blood upwards.

ASCENSION, in *Astronomy*. We understand by the *right ascension* of a star, that degree of the equator, reckoned from the beginning of Aries, which comes to the meridian with the star. By the right ascension and declination, the situation of stars in the heavens is determined, as that of places on the earth by longitude and latitude. By *oblique ascension*, we understand that degree of the equator, counted as before, which rises with the star, in an oblique sphere.

ASCENSIONAL DIFFERENCE, is the difference between the right and oblique ascension of the same point in the sphere. It is sometimes used to describe the space of time the sun rises or sets before or after six o'clock.

ASCENSUS MORBI; the ascent or increase of a disease.

ASCENT OF BODIES. See MECHANICS and ATTRACTION.

ASCIA, in *Anatomy*, a bandage in the form of an axe.

ASCIA; inhabitants of the globe having no shadow, such as those in the torrid zone, who twice a year have their sun at noon in the zenith.

ASCITES; dropsy in the region of the abdomen.

ASE. This term, which is now obsolete, was employed to describe a loathing of food, arising from a diseased stomach.

ASELLI; two stars of the fourth magnitude.

ASEPTA, in *Chemistry*, means a body which has not undergone the putrefactive process.

ASHALTUM. See ASPHALTUM and BITUMEN.

ASHES; the fixed residuum, of a whitish or whitish-grey colour, which remains after the entire combustion of organic bodies, and is no longer able to support combustion. The constituent parts of ashes are different according to the different bodies from which they originate. The ashes of vegetables consist chiefly of earthy and saline ingredients, the latter of which may be separated by washing, and are called *vegetable alkali*. (See ALKALI.) The more compact is the texture of the wood, the more alkali it affords. Some herbs, however, yield more than trees, and the branching fern the most. The more the plants have been dried, the less they produce. The vegetable alkali is always combined with carbonic acid. The greater, therefore, the heat by which the ashes are produced, and the more continued and powerful the calcination of the alkali, the more caustic will it be. It can only be entirely purified from foreign substances by crystallization. (See POTASH.) Of quite a contrary quality are animal ashes, particularly those obtained from bone. After calcination, it retains its original texture, and contains besides lime a peculiar acid, called *phosphoric acid*. The use of vegetable ashes is very extensive, as is well known; soapmakers, bleachers, and other tradesmen use them in

an immense quantity. They are also an excellent manure.

Ash-Pit; that part of a furnace intended to receive the waste fuel.

Ashlar Work; flat stones employed for facing buildings, &c.

Ashler Timbers; wooden beams used to support the roof of a building.

Asiti; an epithet for those abstaining from food.

Asinesia, in *Medicine*, the state of apoplexy or palsy.

Aslani; the Turkish name for a Dutch dollar.

Asmaga; the mixing of a fusible alloy of metal.

Aspalathus; a powerful aromatic occasionally employed in pharmaceutical preparations.

Asparagiu; the fluid extract from asparagus.

Aspasia; a constrictive medicine for the pudenda muliebria.

Aspect, in *Astronomy* and *Astrology*, denotes the situation of the planets and stars with respect to each other. There are five different aspects:—1, sextile aspect, when the planets or stars are 60° distant, and marked thus ⚹; 2, the quartile or quadrate, when they are 90° distant, marked □; 3, trine, when 120° distant, marked △; 4, opposition, when 180° distant, marked ☍; and 5, conjunction, when both are in the same degree, marked ☌. Kepler added 8 more. It is to be observed, that these aspects being first introduced by astrologers were distinguished into *benign*, *malignant*, and *indifferent;* and Kepler's definition of *aspect*, in consequence is, "*Aspect* is the angle formed by the rays of two stars meeting on the earth, whereby their good or bad influence is measured."

Aspect Double. See Optics.

Asper; a Turkish coin equal to three farthings of our money.

Aspera Arteria; the windpipe, so called from the inequality of its cartilages.

Asperginee; medicines administered by external sprinkling.

Asphalitis; the last vertebræ of the loins.

Asphaltum; a soft bituminous pitch found in many parts of the world, but more especially on the banks of the Dead Sea.

Asphyxia; the state of a living man in whom no pulsation can be perceived. It begins with an inactivity of the lungs, which proceeds to the heart and brain. The person appears dead, without breath, pulsation, or feeling. It may be occasioned by different causes, either such as interrupt the mechanical motion of breathing, or such as disturb the action of the lungs themselves. The former may be caused by an external pressure on the breast, if air enters the thorax through wounds, or by an accumulation of blood in the lungs, so that they cannot contract themselves: the latter state takes place if no air at all enters the lungs, as is the case with suffocated, drowned, or hanged persons, or if the air breathed in cannot support life.

Aspiny; a medicinal drug formerly exported in large quantities from Lyons, but now little employed.

Ass; a charge in heraldic coats of arms, where it was the emblem of patience.

Assac, in *Chemistry*, the same as girmini ammoniacum.

Assafœtida; a drug brought from Persia, and occasionally employed in medicine.

Assai; a musical term which indicates that the time must be accelerated or retarded, as *allegro*, quick; *allegro assai*, still quicker; *adagio assai*, still slower.

Assanegi; the powder that falls off from the walls of salt in the salt mines.

Assanus; a weight among the ancients, amounting to two drachms.

Assaron; another name for the measure called in the Scriptures omar.

Assatura; a term descriptive of the poisonous effects ascribed to fresh cooked meat.

Assault, in military affairs, implies the moment of advance, when the attacking party throwing off the protection of their intrenchments, advance single-handed to the combat.

Assay, the metallurgical result of the process of assaying, which see.

Assay-Balance. See Balance.

Assaying, a species of chemical analysis, to ascertain the quantity of gold or silver in a metallic alloy. In its more extended meaning, and in the sense in which we shall adopt it in the following article, it is used for the determination of the quantity of metal in connection with any other mineral employed for practical purposes. The assaying of ores may be performed either by what is termed the dry or moist processes; the first is the most ancient, and, in many respects, the most advantageous, and as such still continues to be generally used.

Assays are made either in crucibles with the blast of the bellows, or in tests under a muffle. The assay weights are usually imaginary, sometimes an ounce represents an hundred weight on the large scale, and is subdivided into the same number of parts, as that hundred weight is in the great; so that the contents of the ore obtained by the assay, shall accurately determine by such relative proportion, the quantity to be expected from any weight of the ore on a larger scale. In selecting the ores, care should be taken to have small portions from different specimens, which should be pulverized, and well mixed in a metal mortar. The proper quantity of the ore is then taken, and if it contain either sulphur or arsenic, it is put into a crucible or test, and exposed to a moderate degree of heat, till no vapour arises from it; to assist this volatilization, a small quantity of powdered charcoal is sometimes added.

To assist the fusion of the ores, and to convert the extraneous matters connected with them into scoria, assayers use different kinds of fluxes. The most usual and efficacious materials for the composition of these are, borax, tartar, nitre, sal ammoniac, common salt, glass, fluor-spar, charcoal powder, pitch, lime, litharge, &c. in different proportions. We may here more particularly mention two or three fluxes. The white flux consists of 1 part of nitre, and 2 of tartar, well mixed together.

The Cornish reducing flux consists of 10 oz. of tarter, 3 oz. and 6 drachms of nitre, and 3 oz. and 1 drachm of borax, mixed well together. These answer every purpose, provided the ores be deprived of all their sulphur; or, if they contain much earthy matters, because, in the latter case, they unite with them, and convert them into thin glass: but if any quantity of sulphur remain, these fluxes unite with it, and form a compound, which has the power of destroying a portion of each of the metals; consequently, the assay under such circumstances must be very inaccurate. The principal difficulty in assaying appears to be in the appropriation of the proper

fluxes to each particular ore, the successful performance of which requires a degree of knowledge that can only be attained by an extensive practice.

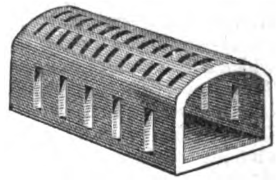
The late celebrated Bergman first suggested the moist process for assaying. It depends upon a knowledge of the chemical affinities of different bodies for each other; and must be varied according to the nature of the ore; it is very extensive in its application, and requires great patience and address in its execution. To enable our readers to understand the process of assaying generally, it may be advisable to furnish a more particular account of both methods.

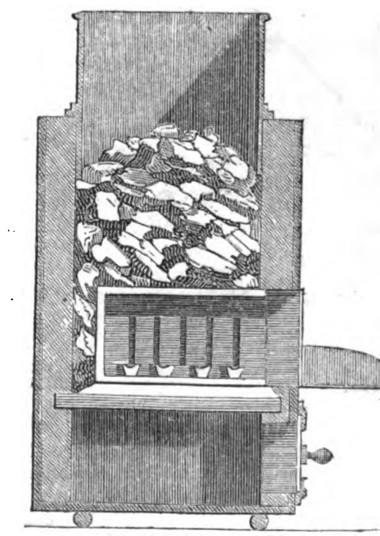
We may commence by pointing out the process for assaying copper ores. The experimentalist should take an exact troy ounce of the ore, previously pulverized, and calcine it thoroughly; stirring it all the time with an iron rod, without removing it from the crucible; after the calcination, an equal quantity of borax must be added, half the quantity of fusible glass, one-fourth the quantity of pitch, and a little pounded charcoal. Cover the mass with common salt, and put a lid on the crucible, which is to be placed in a furnace: the fire is to be raised gradually, till it burns brightly, and the crucible continued in it for half an hour, stirring the metal frequently with an iron rod, and when the scoria which adheres to the rod appears clear, then the crucible must be taken out, and suffered to cool; after which it must be broken, and the regulus separated and weighed; this is called black copper, to refine which, equal parts of common salt and nitre are to be well mixed together. The black copper is brought into fusion, and a teaspoonful of the flux is thrown upon it, which is repeated three or four times, when the metal is poured into an ingot mould, and the button is found to be fine copper.

We may now point out how the process should be performed in the humid way. Make a solution of vitreous copper ore, in 5 times its weight of sulphuric acid, and boil it to dryness; add as much water as will dissolve the sulphate of copper thus formed; in this solution place a clean bar of iron, which will precipitate the whole of the copper in its metallic form. If the solution be contaminated with impure iron, the copper must be re-dissolved in the same manner, and precipitated again.

We come now to the precious metals, which will require a more particular illustration. The experimentalist must take the assay quantity of the ore finely powdered, and after roasting it well, add to the residuum about double the quantity of granulated lead. It must then be put in a covered crucible, and placed in a furnace; raise the fire gently at first, and continue to increase it gradually, till the metal begins to work: if it should appear too thick, make it thinner by the addition of a little more lead; if the metal is too rapidly excited, the fire should be diminished. The surface will be covered by degrees with a mass of scoria, at which time the metal should be carefully stirrred with an iron hook heated, especially towards the border, lest any of the ore should remain undissolved; and if what is adherent to the hook when raised from the crucible, melts quickly again, and the extremity of the hook, after it has become cold, is covered with a thin, shining, smooth crust, the scorification is perfect; but, on the contrary, if while stirring it, any considerable clamminess is perceived in the scoria, and when it adheres to the hook, though red hot, and appears unequally tinged, and seems dusty or rough, with grains interspersed here and there, the scorification is incomplete; in consequence of which, the fire should be increased, and what adheres to the hook should be gently shaken off and returned with a small ladle into the crucible again. When the scorification is perfect, the metal should be poured into a cone, previously rubbed with a little tallow, and when it becomes cold, the scoria may be separated by a few strokes of a hammer. The button is the produce of the assay.

To perform the same process by cupellation, take the assay quantity of ore, roast and grind it with an equal portion of litharge, divide it into 2 or 3 parts, and wrap each up in a small piece of paper; put a cupel previously seasoned under a muffle, of which a representation is given in the accompanying figure, with about 6 times the quantity of lead upon it. When the lead begins to work, carefully put one of the papers upon it, and after this is absorbed, put on a second, and so on till the whole quantity is introduced; then raise the fire, and as the scoria is formed, it will be taken up by the cupel, and at last the silver will remain alone. This will be the produce of the assay, unless the lead contains a small portion of silver, which may be discovered by putting an equal quantity of the same lead on another cupel, and working it off at the same time; if any silver be produced, it must be deducted from the assay. This is called the "witness." The common sort of furnace in which the assay is carried on, is shown in the cut beneath. The muffle and cupels are seen beneath the fuel.





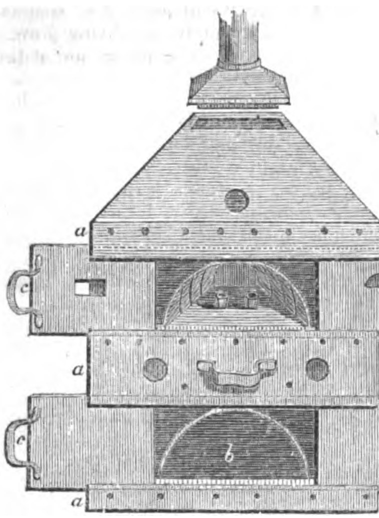
To effect the same thing in the humid way, boil the silver ore in dilute nitrous acid, using about 25 times its weight, until the sulphur is quite exhausted. The silver may be precipitated from the solution by muriatic acid, or common salt. Fixed alkalies precipitate the earthy matters, and the prussiate of

potassa will show if any other metal be contained in the solution.

The general method of examining the purity of silver, is, as we have already seen, by mixing it with a quantity of lead proportionate to the supposed quantity of alloy; by testing this mixture, and afterwards weighing the remaining button of silver. This is the same process as refining silver by cupellation.

It is supposed that the mass of silver to be examined consists of 12 equal parts, called penny-weights; so that if an ingot weighs an ounce, each of the parts will be 1-12th of an ounce; hence, if the mass of silver be pure, it is called silver of 12 penny-weights; if it contains 1-12th of its weight of alloy, it is called silver of 11 penny-weights; if 2-12ths of its weight be alloy, it is called silver of 10 penny-weights, which parts of pure silver are called 5 penny-weights. It must be observed here, that assayers give the name penny-weight, to a weight equal to 24 real grains, which must not be confounded with their ideal weights. The assayers' grains are called fine grains. An ingot of fine silver, or silver of 12 penny-weights, contains then 288 fine grains; if this ingot contain 1-288th of alloy, it is said to be silver of 11 penny-weights and 23 grains; if it contain 4-288ths of alloy, it is said to be 11 penny-weights, 20 grains, &c. Now a certain real weight must be taken to represent the assay-weights: for instance, 36 real grains represent 12 fine penny-weights; this is subdivided into a sufficient number of other smaller weights, which also represent fractions of fine penny-weights and grains.

We have already shown the form of the common furnace, but think it advisable to add a view of another of more general application.



The construction of this very useful furnace is simple, and will readily be understood. Its form is square, terminating in a truncated pyramid. The doors should be provided with handles of some non-conducting material, and the semi-circular apertures shown in the figure are found useful. The fuel is put in at the top.

We may in conclusion notice the mode of assaying ores and earths containing gold. That which is now most generally used is by amalgamation; the proper quantity is taken and reduced to a powder, about 1-10th of its weight of pure mercury is added, and the whole triturated in an iron mortar. The attraction subsisting between the gold and mercury quickly unites them in the form of an amalgam, which is pressed through chamois leather; the gold is easily separated from this amalgam by exposure to a proper degree of heat, which evaporates the mercury and leaves the gold. This evaporation should be made in a furnace with a current of air ascending a pipe in which the mercury is condensed.

This is the foundation of all the operations by which gold is obtained from the rich mines of Peru, Mexico, and other parts of South America.

Assembly, in military operations, the second beat of the drum before the march.

Assers, in *Architecture*, laths which support the tiles of the roof, in imitation of which the dentils were made.

Assident Signs; symptoms which occasionally attend any disease to which the human frame is incident.

Assignable Magnitude; any finite magnitude.

Assignable Ratio; the ratio of finite quantities.

Assignat; the name of the national paper currency in the time of the French revolution. Four hundred millions of this paper money were first struck off by the constituent assembly, with the approbation of the king, April 19, 1790, to be redeemed with the proceeds of the sale of the confiscated goods of the church. August 27, of the same year, Mirabeau urged the issuing of 2000 millions of new assignats, which caused a dispute in the assembly. Vergasse and Dupont particularly distinguished themselves as the opponents of Mirabeau. They saw that the plan was an invention of Clavière (of whose work the speech of Mirabeau was only an extract), to enrich himself and his adherents; that it would tend to put the rich usurers in possession of the wealth of the nation, which would be insufficient to redeem the assignats, particularly if they were increased. Among other arguments, Mirabeau maintained the expediency of the measure he proposed, on the ground that the holders of assignats would necessarily support the new constitution, which was the only guarantee for the redemption of the assignats. His exertions were seconded by Pethion, and 800 millions more were issued. They were increased by degrees to 40,000 millions, and the currency after a while became of no value. It was a common thing to employ this species of paper money as a lining for rooms.

Assimilation, in *Medicine*, an action by which the nourishment assimilates with the thing nourished. It differs only in name from nutrition. See Aliment and Absorbent.

Assis, in the Egyptian pharmacopœia, a pill prepared from hemp leaves.

Assis, in *Heraldry*, sejant, or sitting, as a lion assis affronté, or sejant gardant affronté.

Assistentes, the prostrate glands; so called because they lie near the bladder.

Association of Ideas; that connection between certain ideas which causes them to succeed each other involuntarily in the mind.

Assodes; a fever with excessive inward heat, though not so great externally. It is arranged by Cullen under the tertian remittents.

Assumption, in *Logic*, the postulate or thing supposed, which is the minor proposition in a syllogism.

Assumptive Arms. See Arms in *Heraldry*.

Assurance. See **Insurance.**

Astazof; an ointment of spemisla and houseleek.

Astchachilos; a gangrenous ulcer at the lower part of the feet.

Asterion, in *Astronomy*, the canis venaticus.

Asterism; a constellation of fixed stars.

Astern; behind a ship, as opposed to ahead; which implies the fore-part of the vessel.

Asteroides; the newly discovered planetary bodies. See **Astronomy.**

Asthma. This disease has not unaptly been called the plague spot of our climate, and as such it may be advisable to enter rather more fully into its symptoms and treatment than we usually do in our medical articles. It is of two kinds, the dry, and the humid or common asthma.

Asthma, observes Dr. Good, is more commonly a disease of the later than the earlier period of life; for it does not often appear in infancy or youth, although occasional instances of this have occurred, particularly in infancy, and have been mistaken for cases of croup, which the asthma of infancy very much resembles, though admitting of a more easy cure. It soon becomes habitual, and seems sometimes to be hereditary. It invades all temperaments, but more particularly the melancholic, or that which is a compound of the melancholic with the sanguineous.

The paroxysms of asthma are universally preceded by languor, flatulency, head-ache, heaviness over the eyes, sickness, disturbed rest, and a sense of fulness and anxiety about the præcordia. "When the evening approaches," says Dr. Bree, who unhappily described from his own history, "the weight over the eyes becomes more oppressive, and the patient is very sleepy. Frequently at this period there is a tingling and heat in the ears, neck, and breast. When an asthmatic person feels these warnings, he may be convinced that his enemy is at hand."

The accession is usually about the middle of the night, and during the first and deepest sleep: the cause of which may be thus explained. Respiration always takes place most easily in a raised or erect position, but in the night the body is recumbent. Respiration is also so much of a voluntary action, that although it continues during sleep, and when the will is not exerted, it is considerably aided by the concurrence of the will. Now, during sleep, this concurrence is wanting; and hence the most favourable period for the attack of this insidious complaint is that in which we actually find it makes its appearance—during a recumbent position of the body, when the muscles of respiration are destitute of the stimulus of volition. When the disease, indeed, has once established itself and become habitual, it will recur at other times also, but less frequently.

For the most part, the patient wakes suddenly, and feels a most distressing tightness about the chest, as if he were bound with cords: his anxiety is inexpressible, and he labours for breath as though every moment would be his last. He is obliged to sit erect, breathes distressfully with a wheezing sound, and cannot bear the weight of the bed-clothes. Cool fresh air is the object of his intense desire. At the same time the extremities are cold; the heart palpitates; the pulse is sometimes quickened, but usually weak, irregular, and often intermitting.

In treating asthma, attention must be directed to the paroxysm itself, and to the nature of the constitution after the paroxysm has ceased.

Dr. Cullen, who paid considerable attention to humid asthma, and who regarded plethora and turgescence of the blood-vessels as the usual cause, recommends blood-letting in the first attack, and especially in young persons; with the use of acids and neutral salts, as employed by Sir John Floyer, for the purpose of taking off the turgency of the blood. But the relief it affords, even in dry convulsive asthma, is very temporary; and Dr. Cullen allows that it cannot be persevered in without undermining the constitution and laying a foundation for dropsy. Dr. Bree regards it as a doubtful operation in the first species, or that, to adopt his own language, produced by ærial irritation, and as always imprudent in the second.

In this last, "I have repeatedly," says he, "directed it; but I have never had reason to think that the paroxysm was shortened an hour by the loss of blood: and I have often been convinced that the expectoration was delayed, and that more dyspnœa remained in the intermission than was common after former paroxysms. In old people, who have been long used to the disorder, it is certainly injurious. When, indeed, the disease is secondary, and depends evidently upon an overloaded liver or stomach, or some suppressed evacuation, active cathartics, and especially such as operate simply, will be of great use; and the increased action excited in the alvine canal will often take off the irregular action in the chest; but where the asthma is idiopathic, and especially where the constitution is infirm, as in old age, a powerful alvine irritation will exacerbate the spasm of the chest instead of diminishing it. In exciting nausea or vomiting, however, the patient may be less cautious; for each has often been found highly advantageous in both species of idiopathic asthma. The first, by diminishing generally the living power, and hereby relaxing the convulsive active, and at the same time determining to the surface. Riverius employed vomiting. Dr. Akenside was much attached to the practice of both; he vomited freely on the accession of the paroxysm, and often continued the same plan for a fortnight or three weeks, by giving from five to ten grains, or even a scruple of ipecacuana every other morning. Sir John Floyer extended the time beyond this, though he did not repeat the dose so frequently. He advises the operation of vomiting once in a month. Sedatives and antispasmodics have been found of considerable advantage.

Blistering may also be made use of, but, like setons or issues, can only be of ulterior advantage, for the fit must be of far more than ordinary length if it continue till the blister has produced vesication. It may, however, go far to prevent or shorten a relapse on the ensuing night; and especially when the disease is connected with an asthmatic habit.

There is no discharge that promises such direct benefit as that from the excretories of the bronchial vessels themselves; so is there no tribe of medicines on which we can place so much dependance as on expectorants, when judiciously selected and administered. In every kind of idiopathic affection these may be employed with advantage: for if there be a turgescence in the blood-vessels, they will have a tendency to emulge them; if the bronchiæ themselves be surcharged with serum or mucus, they will facilitate their exhaustion; or if their interior tunic be dry and irritable, by taking off the obstruction and restoring the deficient secretion, they will soften and lubricate the irritable membrane.

Of all the medicines, however, which act on the excernents of the lungs, the squill is by far the most to be depended upon. It is indeed a stimulant of the excernent system generally; for there is no part of this system capable of resisting its power: and it is hence necessary to watch its effects upon the kidneys and intestinal canal, and to attemper it with opium or some other guard, if it produce much influence in either of these ways; except, indeed, in the case of asthma connected with the phlegmatic habit, which is the only modification of the disease in which this collateral influence is found to be of advantage. Squills have also a peculiar tendency to stimulate the stomach, and produce nausea or vomiting; and it rarely shows much of an expectorating power till it has occasioned the former. But as these are advantageous to the disease in both species, and especially in humoural asthma, we are not to discontinue it on this account, but only to moderate its use.

As far as diet is concerned, it may be necessary to state, that the food should be light and cordial without being stimulant; of a solid rather than of a liquid kind; and the meal never be suffered to overload the stomach: all flautulent fruits and other vegetables should be avoided; but oranges, the alliaceous esculents, and the aromata may be allowed in moderation. Hot liquors should be sedulously abstained from; and the beverage consist chiefly of coffee, ginger-tea, and acidulated waters.

ASTRÆA. See VIRGO.

ASTRAGAL. See ARCHITECTURE.

ASTRAGAL, in *Gunnery*, the corner ring of a piece of ordnance.

ASTRAGALUS; the superior and first bone of the foot. See ANATOMY.

ASTRALISH; the ore of gold in its earliest state.

ASTRICTA; an epithet applied to the stomach in opposition to a state of relaxation.

ASTRICTION; the operation of astringent medicines.

ASTRICTORIA. See ASTRINGENTIA.

ASTRINGENTS; medicines of a binding character, such as the mineral acids and solutions of iron, zinc, and lead. The bark is also highly astringent.

ASTRINGENTIA; those things which have a binding quality, as Peruvian bark, &c.

ASTROBOLISMOS; another word for apoplexy.

ASTRODICTICUM; an instrument for several persons to view the stars at the same time, invented by Mr. Weighel.

ASTROGNOSIA; a knowledge of the fixed stars.

ASTROGNOSY, the science which teaches the constellations, ranks, &c., of the stars. (See ASTRONOMY.)

ASTROLABE, an instrument for measuring the degrees, minutes, and sometimes even the seconds, of angles. It generally consists of a horizontal circular plate of metal, having those divisions on its extreme circumference. The utmost accuracy may be obtained in the measurement of angles, by means of a peculiar contrivance (vernier), which consists of an arc, on which the smallest divisions of the circle are subdivided as minutely as is requisite in the observations, and as the skill of the maker can graduate it. This arc is moveable, so that it can be fitted to the divisions of the circle. Fixed to this circle are two indexes, provided with telescopes. One of them is immoveable; the other turns round the centre of the instrument. By taking sights from the vertex of the angle, at two fixed points in the direction of its sides, the arc, which measures the angle, is intersected on the circle of the instrument. In modern astronomy, this instrument is no longer used, except in the practical applications of geometry. The first application of the astrolabe to navigation was made by the physicians Roderic and Joseph, and Martin Behaim of Nuremberg, when John II., king of Portugal, desired them to invent a method of preserving a certain course at sea. They taught how to discover the situation of a vessel at sea without the use of the magnetic needle.

ASTROLOGY; an art which pretends to foretell future events, especially the fate of men, from the position of the stars. It is among the oldest superstitions in the world, and, as Bailly conjectures, with great apparent probability, it owes its origin to the influence of the heavenly bodies, particularly the sun and moon, on the seasons, the weather, and the fertility of the earth. This led to the idea that these luminaries were created only for the use of the planet we inhabit, and that, as they have an influence upon the earth, they probably have some connection with the destiny of individuals and of nations. The Egyptians have a tradition that Belus founded a colony from Egypt on the banks of the Euphrates, in Asia; and this colony was furnished with priests, according to the custom of the mother country, who were free from public taxes, and were called by the Babylonians *Chaldees*. Hence it may be conjectured, that astrology was invented by the Egyptians; among whom the inhabitants of Thebes particularly claimed the honour of the invention. Most of the ancient writers are agreed, that astrology was communicated by the Chaldees to other nations. From this circumstance, astrologers used to be called *Chaldees* by the ancient writers; sometimes *Genethliaci* (see GENETHLIACON); and, in later times, *Chaldee* has been synonymous with *astrologer*. (See HOROSCOPE.) The great antiquity of this art may be inferred from the fact, that most astrological observations are founded on the position of the stars in reference to the horizon, which was the first circle recognized in the heavens; also from its being mentioned in the Mosaic history. As astrology in later times fell into disrepute on account of the cupidity and fraud of its practitioners, these assumed the name of *Mathematicians*, by which they were generally known at the time of the Roman emperors. They caused so much trouble, that Tiberius at length banished them from Rome. The law relating to this banishment of astrologers, however, makes a distinction between geometry and what they term the mathematical or astrological art. However objectionable astrology may be in itself, it has been of essential use to astronomy. It has excited more interest in, and led to more careful observations of, the heavenly bodies. During the middle ages, astrology and astronomy were cultivated in connection by the Arabs, and their works on the subject are still extant. Pico of Mirandola, who manfully combatted the errors of astrology towards the close of the fifteenth century, found but little attention paid to his labours. Even in the sixteenth and seventeenth centuries, astrology could boast of literary men, such as Cardano, and even Kepler, among its adherents. The Copernican system, the correctness of which experience has been continually confirming, has shaken the foundations of the ancient science; but the disease is not wholly eradicated.

ASTROMETEOROLOGIA; the art of foretelling weather. See BAROMETER.

ASTRONOMICAL; an epithet for any thing relating to astronomy, as *Astronomical day*, hour, or year, in distinction from the civil day, hour, or year.—*Astronomical characters*, those used in astronomy.—*Astronomical horizon*, in distinction from the sensible horizon.—*Astronomical place of a star* or planet; the longitude of a star or place in the ecliptic, reckoned from the beginning of Aries.—*Astronomical hours;* such as are reckoned from the noon or mid-day to the noon or midnight of another.—*Astronomical observations;* such observations as are made with suitable instruments by astronomers on the heavenly bodies to ascertain their forms, appearances, motions, &c. The observations of Hipparchus, which are the earliest handed down to us from the Greeks, are given in Ptolemy's *Amalgest.*—*Astronomical tables* are computations of the motions, places, and other phenomena of the planets, both primary and secondary. Tables of this description are to be found in Ptolemy's *Amalgest,* which have however been superseded by more modern and correct calculations, the principal of which is the nautical almanack.

ASTRONOMICAL CALENDAR; an instrument consisting of a board on which is pasted an engraved paper, with a brass slider, which carries a fine line, and shows at sight the meridian altitude and declination of the sun.

ASTRONOMICAL QUADRANT; a mathematical instrument for taking observations of the sun.

ASTRONOMICAL TELESCOPE; so called, because it is only used in astronomical observation, consists of an object-glass, and an eye-glass, both convex.

ASTRONOMICAL SECTOR; an instrument for finding the difference in right ascension and declination between two objects whose distance is too great to be seen through a fixed telescope.

ASTRONOMY is the science of the heavenly bodies, and describes their motions, periods, eclipses, magnitudes, &c. The popular modes of illustrating this science, both in the lecture-room and in general treatises, are but of little value to the astronomer; and we purpose in the present article combining the practice of the science with a description of the heavenly bodies, so that our readers may acquire not only a popular view of astronomy, but learn how to determine for themselves the data on which the great truths of this interesting science are founded.

The study of the heavens was undoubtedly coeval with the existence of man, urged by the double impulse of his necessities and fears. In the genial climate, and beneath the serene sky of the East, it seems to have made considerable progress. The great convulsion in the physical world, of which the sacred writings have traced the outline, swept away along with the races of men all the records of their intellectual attainments; but some wrecks of their astronomical knowledge seem to have been preserved either by the durability of the monuments on which they had been engraved, or by the memories of those whom the desolating waters had spared. These precious relics, which time still respeets, inspired the Chaldean, Indian, and Egyptian philosophers with a reverence for astronomy, and formed the epochs of the science which they restored. From Egypt it speedily passed into Greece under the form of mysteries too sacred for the ear of the vulgar, and of allegorical emblems too profound for their understanding. Here it was soon stripped of the mystical drapery in which superstition had swathed it, and the genius of that refined people presented it purified and improved in all their schools of philosophy. In the tenets of Thales, Pythagoras, and their successors, we trace some of the soundest doctrines of modern astronomy, which form a singular contrast with the reveries of solid orbits and the harmony of the celestial spheres.

Astronomy was now destined to receive into the land of its birth all the advantages of royal patronage, and that science, which Rome despised, and which Athens persecuted, found shelter among the sovereigns of Alexandria. The establishment of the Alexandrian school, and the protection and cultivation of the sciences by men who had lived in war, is the most glowing passage in the history of the human mind. It is the romance, indeed, of astronomy which princes should peruse, and which statesmen should engrave upon their heart. The formation of the library of Alexandria; the erection of its observatory; the invitation to his court of the philosophers of every clime; his participation in their conversation and in their labours, and the accessions which astronomy thence derived, have immortalized the name of Ptolemy Philadelphus, while they reflected over the darkness of future times a more intense light than was ever thrown by her blazing Pharaohs upon the shelves of her rugged shores.

Aristarchus, one of the earliest astronomers of this great school, determined that the distance of the sun was at least twenty times greater than that of the moon; and, convinced that the earth moved round the sun, he inferred from the positions of the stars, when the earth was in the opposite points of its orbit, that their distances were immeasurably greater than that of the sun. These important steps in the science were pursued by Eratosthenes, whom Ptolemy Euergetes invited to his capital. With instruments erected by his patron, he found that the diameter of the sun was at least twenty-seven times greater than that of the earth; and by comparing the distance of Alexandria and Syene with the celestial arc between the zeniths of these two cities, he concluded that the circumference of the earth was twenty-five thousand stadia; a result not excessively different from the measurement of modern times. Important as these determinations were to astronomy, yet it was from his successor, Hipparchus, that the science derived the most valuable improvements. Collecting and comparing the observations of his predecessors, he resolved to repeat and to extend them. He ascertained the length of the tropical year; he discovered the equation of time; he fixed the lunar motions with great accuracy, and he determined the eccentricity and the inclination of the moon's orbit. His grand work, however is his *Catalogue of the Longitudes and Latitudes of One Thousand and Twenty-two Fixed Stars;* by means of which he discovered the precession of the equinoctial points. In carrying on these inquiries, he was led to the principles and rules of spherical trigonometry, one of the most valuable branches of geometry. The leading works of this eminent astronomer perished in the flames which destroyed the Alexandrian library, but the most important of his observations have been fortunately preserved in the writings of his successors.

The great advances which were thus made in the science were succeeded by a long interval of dark-

ness, across which a few gleams of light were occasionally thrown. The Alexandrian school, however, still existed; and the consecrated name of Ptolemy, so indelibly associated with its origin, was destined in its latter days to renew its glory. About one hundred and thirty years before the Christian era, Ptolemy devoted himself to the science of the heavens. He discovered the second inequality in the moon's motions; he determined with new accuracy the relative positions of the planets, and their distances from the earth; but rejecting, on the evidence of his senses, the system of Pythagoras, who made the earth the centre of the universe, round which the sun and the whole starry heavens performed their revolutions. This fundamental error led him to explain the stations and retrogrations of the planets, and the other celestial motions, by the cumbrous machinery of epicycles, which so long deformed the science and retarded its advancement. The subject of astronomical refractions received also from Ptolemy a satisfactory explanation; but though he rendered such signal services to astronomy, as well as to the science of optics, dialling, and music, yet his name will for ever be connected with a false system of the universe; and his assiduity as an observer will always be placed in disagreeable contrast with that defect of sagacity which had thus marked his astronomical speculations.

With the life of Ptolemy terminated the labours of the Alexandrian school. Centuries rolled on amid intellectual darkness: ambition pursued her bloody course, and superstition continued to offer her unholy sacrifice; but no gifted spirit arose to vindicate the science of the heavens from its degraded state. Even the accumulated knowledge of former times perished in the conflagration of the Alexandrian library; and though the tears of the victorious caliph flowed in repentance, yet they were a poor compensation for the havoc of his arms.

But while the Arabs had thus wantonly violated the sanctuary of science, their own land was ordained to be the scene of its triumphs. Astronomy was again received into the palaces of kings, and Almansor, Al Raschid, and Almamon, were its cultivators as well as its ardent patrons. The rays of science gilded the minarets of Bagdad when they had ceased to shine on benighted Europe. The Amalgest of Ptolemy was recovered from the Greek emperor by force of arms; and several works were composed and observations made, which powerfully contributed to the science of astronomy. Even in Persia and Tartary, associations of astronomers were formed by the command of their princes; magnificent instruments were erected at the royal expense; and catalogues of the fixed stars, and astronomical tables of singular accuracy proceeded from the pen of the grandson of Tamerlane the Great. From the East, astronomy passed with the arms of the Arabs into Spain, where it received valuable additions from the genius of Alhazen and Alphonso X. The Alphonsine Tables, indeed, which appeared in 1252, are to this day a monument of the knowledge and liberality of the Castilian king. We now approach the era of reviving science. Many astronomers of inferior note paved the way, by valuable, though insulated observations, for the great restorer of astronomy. Copernicus, who was born in 1437, was not the author of any remarkable discovery; but by a diligent comparison of the discoveries of his predecessors, by sagacious views of the simplicity of nature, and by a just perception of the relations which ought to exist among the various bodies of the system, he was led to place the sun in the centre of the universe, and to account for the daily revolution of the celestial sphere by the motion of the earth upon its axis. This slight change upon the Ptolemaic system banished the epicycles and eccentrics of his predecessors, and every phenomenon in the general motions of the heavens received an immediate explanation. The publication, therefore, of the *Astronomia Instaurata* in 1530, forms a principal epoch in the history of astronomy. The true solar system was now established, and the various planets which the unassisted eye could discover in the heavens, were placed in their proper spheres, and nearly at their proper distances from the central luminary; while the fixed stars, separated from our planetary universe, were thrown back into the depths of space, to become in their turn the objects of a more refined philosophy.

Hitherto astronomy was merely a science of observation, and no stretch of mind was required to comprehend its principles or its details. It was now destined to take a higher and a wider flight, and to call into its service the most profound and varied acquirements. The subject of the refraction of the atmosphere had formed a slight connection between astronomy and optics; but the invention of the telescope now bound these sciences together by an indissoluble tie, and from the latter the former derived all its subsequent discoveries. In a few years the ring of Saturn and nine secondary planets rewarded the labours of Galileo, Huygens, and Cassini; and the application of the pendulum to clocks by Huygens furnished the astronomer with one of his most valuable instruments. The period, however, of which we now treat has derived its distinctive feature from the determinations of the laws of the planetary motions by Kepler and Newton. Fond of analogies, Kepler directed his mind to the discovery of general laws: he found that all the planets revolved in elliptical orbits, in one of the foci of which the sun was placed. He discovered that the line which joined the sun and the planet described equal areas in equal times; and by comparing the powers of the numbers which represent the periods and the distances of the planets, he determined that the squares of their periods round the sun, varied as the cubes of the greater axes of their elliptical orbits. These great discoveries paved the way for views still more comprehensive. Kepler had been indulged with a faint glimpse of the mutual tendency of all bodies to one another; and Dr. Hook went so far as to show that the motions of the planets were produced by the attractive agency of the sun, combined with the force which had originally projected them: but it was reserved for Newton to establish the law of universal gravitation in its entire generality, and to apply it with demonstrative evidence to all the movements within the solar system. In assimilating the power by which the apple falls from the tree, to that which retains the moon in her orbit, Newton made the first step in this great generalization. He soon perceived that all the other satellites revolved round their primary planets in virtue of their attraction, and that the primary, along with the secondary planets, were carried round the sun by the agency of his predominating attraction. Hence, he was led to deduce the general principle, that all material bodies attract each other with a

force directly proportional to the number of their particles, and inversely proportional to the squares of their distances. The tides, the spheroidical form of the earth, the precession of the equinoxes, and the irregularities of the lunar motions, received from this comprehensive proposition, an immediate explanation; and the laws of the material universe, rescued from the schools of a false philosophy, were now fixed upon an imperishable base.

If England may be permitted to cast a proud eye upon the period we have been considering, she cannot but contemplate with the bitterest dejection that which succeeded it. As if Providence decreed that there should be a balance in the glory, as well as in the power of nations, no British name has been allowed to share in the intellectual triumphs which illustrated the middle and the close of the eighteenth century. Truth and justice demand from us this afflicting acknowledgment, while they award to Clairaut, Euler, D'Alembert, Lagrange, and Laplace, the highest honour of having completed the theory of the system of the world.

The problem of two bodies, or the determination of the motions of one planet revolving round another, had received from Newton the most perfect solution. He had even shown that the problem of three bodies, in which the action of a disturbing planet is introduced, could be resolved by the principles which he had established; and in the case of the lunar irregularities, he had succeeded in explaining no fewer than five of the most important. At this point, however, the powers of analysis failed, and it was left to a succeeding age to complete the noble edifice which he had founded. The results of the labours to which we allude, are developed in the *Mécanique Céleste* of Laplace, a work which ranks next to the *Principia*; but it would exceed our limits were we to assign to each of the astronomers we have named their respective claims to immortality. By the improvements they have made in the analytical art, they have solved the problem of three bodies, and have computed, with an accuracy almost miraculous, the various disturbances which affect the motions of the principal planets.

But though the spirit of English science had thus been slumbering amid the intrigues of faction, and the apathy of short-lived and unenlightened administrations, the exertions of individual genius were preparing in secret for new achievements. The invention of the achromatic telescope by Dollond, and the improvement of reflectors by Short and Mudge, had armed the observer for the great subject of sidereal astronomy; for examining the phenomena and condition of the stars, and the structure of the groups and systems which the telescope descried in the immensity of space. In this period, doubtless the most brilliant in the annals of discovery, the name of Herschel stands in proud pre-eminence as the founder and the most successful cultivator of sidereal astronomy; and when we add the name of his accomplished son, of Dr. Brinckley (Bishop of Cloyne), of Sir James South, and of Mr. Struve, we complete the list of great men who have immortalized themselves in this difficult and boundless field of inquiry. Before we proceed to give an account of their labours, it is necessary that the reader should have some idea of the distance and magnitudes of the bodies which are to come under his consideration. That the nearest of the fixed stars are not placed at immeasurable distances, has been fully established by the numerous and ably conducted observations of the Bishop of Cloyne.

It was to regions so remote, and to bodies so vast, that Sir William Herschel directed his powerful telescopes, after he had extended the limits of our own system, by the discovery of one primary and eight secondary planets. Professor Kant and the celebrated Lambert had suggested the hypothesis, that all the bodies in the universe were collected into nebulæ, and that all the insulated and scattered stars formed part of the nebulæ to which our own system belonged. Pursuing this happy thought, Sir William Herschel examined no fewer than 2,500 nebulæ, and he was led to the opinion that the galaxy, or milky-way, was the projection of our own nebulæ in the sky; and by gauging the heavens, or counting the number of stars which occur in the same space in different directions, he was enabled to determine the probable form of the nebulæ itself, and the probable position of the solar system within it. But while this idea impresses us with its grandeur, it at the same time furnishes us with a scale for estimating the immensity of nature. If all the separate stars which the most powerful telescope can descry, are only part of our own nebulæ, what must we think of the millions of nebulæ, some of which exhibit by their proximity the individual stars of which they are composed? while others, as they recede from our failing sight, display only in the best instruments a continuous and unbroken light, in which the spaces between the stars can no longer be seen. From the systems which roll within these groups of worlds, a new firmament of stars will be seen, and each system will have its milky-way, exhibiting the projection of its nebulæ, varying in form and in lustre with its locality within the group. It is in vain to pursue ideas so vast and overwhelming: it is enough that the mind tries its strength, and stands self-convicted of its weakness.

Let us, therefore, turn our attention to nearer objects—to our own nebulæ, and the stars which compose it. Not content with determining the probable position of the solar system within the nebulæ of the milky-way, Sir William Herschel conceived the idea of ascertaining whether that system was stationary or moveable. By a comparison of the proper motions of the fixed stars, he determined that the solar system was advancing towards the constellation Hercules; and that if it were viewed from one of the nearest of the fixed stars, the sun would appear to describe an arch of about one second. In reasoning respecting the insulated stars, which belong to what we may now call the solar nebulæ, he justly conceived that those which were double must form binary systems, or systems in which the two stars revolve round their common centre of gravity. These views, at first entirely speculative, received from subsequent and long-continued observation a very remarkable confirmation. If we suppose a line to join the centres of the two stars which compose a double star, then if the two stars have no relative motion, this line must form an invariable angle with the line or direction of their daily motion. By means of an ingenious position-micrometer, Sir William Herschel determined this angle (called the angle of position) for seven hundred and two stars, between 1778 and 1784. After a lapse of twenty years, he repeated his observations on the same stars, between 1800 and 1805, and

he had the satisfaction of finding that in more than fifty double stars there had been a decided change, either in their distance or in their angle of position. In this way he discovered that one of the stars of Castor revolved round the other in 342 years; that the small star of γ, Leonis, performed its circuit in 1200 years; that of ϵ, Boötes, in 1681 years; that of δ, Serpentis, in 375, and that of γ, Virginis, in 708 years. By this great discovery, the greatest unquestionably in the history of astronomy, the existence of systems among the fixed stars was completely established; but so far did Sir William Herschel's labours transcend those of the age in which he lived, that no attempt was made to repeat and to extend them. They were scarcely admitted into any astronomical work; they were ridiculed by men whose reputation had been eclipsed by his own; and they were received with a sort of incredulous wonder, even by the most ardent lovers of astronomy. The progress of knowledge and of discovery had paved the way not only for the highest achievements of Newton and Laplace, but also for their immediate reception among philosophers; and had these great men never lived, science would in a few years have received from other minds the same splendid accessions. The discoveries of Herschel, on the contrary, exhibited no continuity with those of his predecessors. Before his day sidereal astronomy had no existence; nor had the wildness of speculation ventured even to foreshadow its wonders. Entrenched in the remoteness of space, and among spheres which no telescope but his could descry, her walls were unscaled, and her outworks even unapproached. His genius, however, enabled him to surmount barriers hitherto impregnable, and conducted him in triumph into the very stronghold of her mysteries. The cessation of such gigantic labour would have been afflicting to science, had not that same wisdom which provided for the continuity of his name, provided also for the continuity of his labours.

In the year 1816, four years before the death of his venerable father, Mr. (now Sir John) Herschel, had begun a re-examination of the double stars, and had made some progress in it. The same idea had occurred to Sir William South, one of the most able and enterprising astronomers of the present day, and it was agreed that they should undertake the work in concert. They accordingly began in March 1821, and continuing their observations in 1822 and 1823, they were able to communicate to the Royal Society in January 1824, the position and apparent distances of 380 double and triple stars, the result of above 10,000 individual measurements. The instruments which they employed were two achromatic telescopes mounted equatorially: the object-glass of the smallest had an aperture of three inches and three quarters, and a focal length of five feet, and was made by the late P. and J. Dollond. The power usually employed was 133, but powers of 68, 116, 240, and 381, were sometimes used. The largest telescope was seven feet in focal length, with an aperture of five inches, and is supposed to be the best that Mr. Tulley ever executed. The power commonly employed was 179, though 105, 273, and sometimes 600 were used.

No sooner had Sir William South completed his share in this great work, than he began another series of observations of equal difficulty and importance. They were made principally at Passy, near Paris, with the instruments above mentioned; and in November, 1825, he communicated to the Royal Society the apparent distances and positions of 458 double stars, of which 160 had never before beer observed.

While these observations were going on in England, an able continental astronomer, M. Struve, director of the Imperial Observatory at Dorpat, in Livonia, had occupied himself with the same subject; and such was his assiduity and zeal, that in four years he completed his *Catalogus Novus Stellarum Duplicium et Multiplicium*, containing no fewer than 3063 stars. These observations were chiefly made with a telescope by Frauenhofer, which the Emperor of Russia had presented to the observatory of Dorpat. This magnificent instrument has a focal length of thirteen feet, and an aperture of nine inches, and cost thirteen hundred pounds. The King of Bavaria followed this noble example, by ordering a still finer instrument for the same purpose.

The early history of astronomy was, as we have seen, fraught with error; but observation has now enabled us to trace with mathematical accuracy the forms and motions of the heavenly bodies. The planets known as forming part of our system are eleven in number, and we cannot do better than enumerate them in the order in which they follow from the sun; omitting however our earth, which will be the subject of a more minute examination, with especial reference to the phenomena of the seasons, day and night, &c. It may be right to observe, that all the planets move round the sun from east to west, and the paths in which they move are called their orbits.

The one whose orbit is nearest to the sun, is called *Mercury*. When seen through a telescope, it sometimes appears in the form of a half moon, while at other times a little more or less than half its disc is seen; hence it is inferred, that it has the same phases as the moon, except that it never appears quite round, as its enlightened side is only turned directly towards the earth when it is so near the sun as to become invisible on account of the splendour of the sun's rays. The enlightened side of this planet being always directed towards the sun, and it never appearing round, are evident proofs that it shines by reflected light. The best observations of this planet are those made when it is seen on the sun's disc, called its transit; for in its lower conjunction, it sometimes passes before the sun, like a small spot, eclipsing a part of the sun's body.

Mercury performs its periodical revolution round the sun in 87 days, 23 hours, 15 minutes, 43 seconds; its greatest elongation is 28° 20′, distance from the sun 36814721 miles; the eccentricity of its orbit is estimated at one-fifth of its mean distance from the sun; its apparent diameter 11′; hence its real diameter is 3108 miles; and its magnitude about one-sixteenth of the magnitude of the earth.

Mercury emits a bright white light; it appears a little after sun-set, and again a little before sun-rise; but on account of its nearness to the sun, and the smallness of its magnitude, it is seldom seen. The light and heat which this planet receives from the sun, are about seven times greater than the light and heat which the earth receives. The orbit of Mercury makes an angle of seven degrees with the ecliptic, and it revolves round the sun at the rate of upwards of one hundred and nine thousand miles per hour.

Venus is the second planet. When viewed through a good telescope, it has a very pleasing appearance. At the time of its greatest elongation, it appears like the moon in the quadratures; one half of its disc being enlightened. In the inferior part of its orbit, as its elongation decreases, the enlightened part becomes less. After passing the inferior conjunction, the planet is again seen crescent-shaped, but the illuminated part continues to decrease, and at the greatest elongation half its disc is again seen enlightened. In the superior part of its orbit, as its elongation decreases, its face becomes more full and round, till the superior conjunction, after which time it is again diminished by the same gradation as its increase was in the former case accomplished. There is no difficulty in accounting for this variety of phases, it being occasioned by the different positions of Venus with respect to the Sun and Earth; for as the enlightened face of Venus must of course be always opposite to or facing the sun, it will be more or less visible to us according to our situation at various times.

The surface of Venus is diversified with spots like our moon, by the motion of which it is determined, that it revolves on its axis from east to west in the space of about twenty-three hours. Under favourable circumstances, mountains like those in the moon may, it is said, be discerned with a very powerful telescope.

A body which weighs one pound at the equator of the earth, would, if removed to the equator of Venus, weigh only 0.98 pound.

The proportion of light and heat which she receives from the sun is about 1.91 times greater than that received on the earth.

As viewed from the earth, Venus is the most brilliant of all the planets; and may sometimes be seen with the naked eye at noon day. She is generally known as the morning and evening star, and never recedes far from the sun. The mean distance of Venus from the sun is 0.7233316; that of the earth being considered as unity. This makes her mean distance nearly 68 millions of miles.

Passing our earth, which will be fully noticed hereafter, we come to the planet *Mars*, which is peculiarly distinguished by its dusky red colour. By the spots on *Mars*, its diurnal revolution is ascertained in the direction from west to east. From the ruddy and obscure appearance of this planet, as well as from other appearances, it is concluded that its atmosphere is nearly of the same density as that of the earth. Herschel has observed, that two circles surrounding the poles of this planet are very white and luminous, probably from snow lying there. The mean distance of Mars from the sun is 1.5236923; that of the earth being considered as unity. This makes this mean distance above 142 millions of miles. He performs his mean sidereal revolution in 686.9796458 mean solar days; or in 686 days, 23 hours, 30 minutes, 41 seconds, 4: and his mean synodical revolution in 779.936 mean solar days.

A body which weighs one pound at the equator of the earth, would, if removed to the equator of Mars, weigh only one-third of a pound.

The proportion of light and heat received by him from the sun is about 0.43; that received by the earth being considered as unity.

He is not accompanied by any satellite, and is known by his red and fiery appearance.

His course sometimes appears retrograde. The arc which he describes in such cases varies from 10° 6′ to 19° 35′: its duration in the former case is 60 days, 18 hours; and in the latter case 80 days, 15 hours. This retrogradation commences or finishes when the planet is at a distance from the sun, which varies from 128° 44′ to 146° 37′.

The next planet in our system is *Vesta*, for the knowledge of which we are indebted to Dr. Olbers of Bremen, being first discovered by him, March 29, 1807. Its distance from the sun is about 223 millions of miles, and its annual revolution in its orbit is performed in 3 years, 7½ months. But neither has its diameter, nor the duration of diurnal rotation, been yet ascertained.

Juno, the next in order, is another new planet; discovered by Mr. Harding, at the observatory at Lilienthal, near Bremen, September 1, 1804. The mean distance of this planet from the sun is estimated at 253 millions of miles, and its annual revolution is performed in 4 years, 4 months, and 6 days; but its diameter, and the time of its revolving on its axis, are unknown.

Ceres was first discovered by Piazzi of Palermo, January 1, 1801. Its mean distance is nearly the same as that of Pallas, and consequently its annual revolution is performed in nearly the same time.

The next superior planet is *Pallas*, which was first observed by Dr. Olbers, March 8, 1812: the mean distance of which from the sun is reckoned to be about 263 millions of miles, and its revolution in its orbit is made in about 4 years, 7 months, and 10 days; but, like the two former, its diameter and diurnal rotation have not as yet been correctly ascertained.

Jupiter is, next to Venus, the most brilliant of the planets, and sometimes even surpasses it in brightness. Its apparent diameter at its mean distance from the earth is 36″. Its figure is an oblate spheroid, the proportion of its equatorial to its polar axis being about 14 to 13. Laplace from theory deduces this proportion to be 1,000,000 to 9,286,922, the result obtained from computing the effect of the equatorial regions of the planet in disturbing the nodes of the satellites. When seen through a telescope, this planet exhibits a very remarkable appearance, its surface being covered with a number of belts or stripes of various shades. These appearances differ much at different times, and even at the same time in telescopes of different powers. These belts were first observed at Naples by Zuppi and Bartoli, two Jesuits; and about the year 1660, they were observed by Campini, with refracting telescopes of his own construction, and not much inferior in distinctness to those of the present day; the great modern improvement in refracting telescopes consisting rather in the reduction of their size than in the increase of their magnifying power.

Jupiter is accompanied by four satellites, which were discovered by Galileo, the 8th of January 1610. He at first took them for telescopic fixed stars; but continued observation soon convinced him that they really accompanied the planet. The relative situation of these small bodies changes at every instant: they oscillate on each side of the planet, and it is by the extent of these oscillations that the rank of these satellites is determined; that being called the first satellite, whose oscillation is the least. They are sometimes seen to pass over the disc of the planet,

and project a shadow in the form of a well-defined black spot, which then describes a chord of this disc.

Jupiter and his satellites, therefore, are opaque bodies, enlightened by the sun; and when the latter interpose between the sun and Jupiter, they produce real solar eclipses, precisely similar to those which the moon occasions on the earth.

These phenomena lead to the explanation of another which the satellites present. They are often observed to disappear, though at some distance from the disc of the planet: the third and fourth reappear sometimes on the same side of the disc.

The shadow which Jupiter projects behind it (relatively to the sun) is the only cause that can explain these disappearances, which are perfectly similar to eclipses of the moon. The circumstances which accompany them leave no doubt of the reality of this cause. The satellites are always observed to disappear on the side of the disc opposite to the sun, and consequently on the same side to which the conical shadow is projected. They are eclipsed nearest the disc, when the planet is nearest to its opposition.

Finally, the duration of these eclipses answers to the time which should elapse while they transverse the shadow of Jupiter.

Thus it appears that these satellites move from west to east in returning orbits round the planet. Observations of their eclipses are the most exact means of determining their motions. Their mean sidereal and synodical revolutions, as seen from the centre of Jupiter, are very accurately determined by comparing eclipses at long intervals from each other, and observed near the opposition of the planet.

Saturn can hardly be seen by the naked eye. When examined by a telescope, it exhibits a very remarkable appearance. It is surrounded by a thin, flat, broad, luminous ring, which encompasses the body of the planet, but does not touch it. This ring casts a strong shadow upon the planet, and is divided into two, by a distinct line in the middle of its breadth. The rings are circular, but appear elliptical from being viewed obliquely.

According to Dr. Herschel, the dimensions of the rings, and the space between, are as follow:

	Miles.
Inner diameter of the smaller ring . . .	146,345
Outside diameter of ditto	184,393
Inner diameter of the larger ring	190,248
Outside diameter of ditto	204,883
Breadth of the inner ring	20,000
Ditto of the outer ring	7,200
Ditto of vacant space	2,839

Besides this ring, Saturn has seven moons of different sizes, and its body is surrounded also by belts, like those of Jupiter.

The mean distance of this planet from the sun is 9.5387861; that of the earth being considered as unity. This makes its mean distance about 890 millions of miles. His mean sidereal revolution is performed in 29.456 Julian years. The rotation on his axis is performed in about ten hours and a half. His true diameter is about 76068 miles.

Uranus, or the *Georgium Sidus*, is the last planet known in our system. It was discovered by Sir William Herschel, March 13th, 1781, who gave it the name which it now bears. It performs its sidereal revolution in about 30,686 mean solar days, or in about 84 Julian years.

Its distance from the sun is upwards of nineteen hundred millions of miles; and its apparent diameter is scarcely 4",0.

Six satellites accompany this planet, which move in orbits nearly perpendicular to the plane of the ecliptic.

The sizes and relative situations of the *sun*, *earth*, and *moon*, will now engage our attention. It will hardly be necessary to state that the first of these great bodies forms the centre of our system, round which the planets and satellites revolve, or rather round the common centre of gravity of the entire series.

The first thing that strikes the mind when contemplating this glorious orb, is its astonishing magnitude. This vast globe is found to be about 882,000 miles in diameter, and, consequently, contains a mass of matter equal to more than thirteen hundred thousand spheres the size of our earth.

The only motion which an ordinary observer can trace in the sun is one of rotation, on its axis in the space of rather more than twenty-five days. This motion has been ascertained by means of a variety of dark spots, which are discovered by the telescope on the sun's disc. They first appear on his eastern limb, and after a period of about thirteen days, disappear on his western. These spots vary both in number, magnitude, and shape; sometimes 40 or 50, and at other times only one or two are visible. Most of them have a very dark nucleus, or central part, surrounded by an umbra, or faint shadow. Some of the spots are as large as would cover the whole continent of Europe; and one was seen in the year 1779, which was computed to be more than fifty thousand miles in diameter. With regard to the nature of this globe, it appears highly probable, from the observations of Sir William Herschel, that the sun is a solid and opaque body, surrounded with luminous clouds which float in the solar atmosphere, and that the dark nucleus of the spots is the opaque body of the sun appearing through occasional openings in its atmosphere.

The following are Sir Isaac Newton's observations on the sun; 1. That its heat is seven times greater in Mercury than with us, and that water there would immediately disappear in the state of vapour. 2. That the quantity of matter in the sun is to that of Jupiter as 1100 to 1; and that the distance of Jupiter from the sun is in the same ratio to the sun's diameter; consequently the centre of the sun and Jupiter is nearly in the superfices of the former. 3. That the quantity of matter in the sun is to that of Saturn as 2360 to 1; and the distance of Saturn from the sun is in a ratio little less than that of the sun's semi-diameter, so that the common centre of gravity of Saturn and the sun is a little within the latter. 4. Hence the common centre of gravity of all the planets cannot be more than the length of the solar diameter from the centre of the sun.

From other observations, which we cannot detail without far exceeding our prescribed limits, Sir W. Herschel was induced to suppose, that the appearance of copious spots indicated the approach of warm seasons on the surface of the earth; and he endeavoured to maintain this opinion by historical evidence; connecting the varying temperature of our atmosphere with the appearance and disappearance

of the solar spots. The spots or shallows, which our author considers as parts of an inferior stratum, consisting of opaque clouds, are capable of protecting the immediate surface of the sun from the excessive heat produced by combustion in the superior stratum, and perhaps of rendering it habitable to animated beings. But if stars are suns, and suns are habitable, a very extensive field of examination is thus opened to our view.

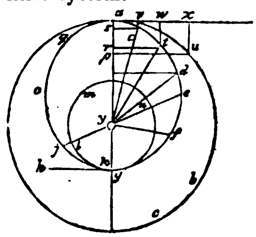
Some distinguished philosophers, among whom we may reckon Sir Isaac Newton, consider the sun's rays as composed of small particles, which move with uniform velocities in uniform mediums, but with variable velocities in mediums of variable densities. These particles, they say, act upon the minute constituent parts of bodies, not by impact, but at some indefinitely small distance; they attract and are attracted; and on being reflected or refracted, they excite a vibratory motion in the component particles. Others, represent fire as a substance sui generis, unalterable in its nature, and incapable of being produced or destroyed; natually existing in equal quantities in all places, imperceptible to our senses, and only discoverable by its effects, when it is collected in a less space than that which, from its tendency to an universal and equable diffusion, it would otherwise occupy. It has also been argued, that the matter of the sun's rays is not derived from the sun in any shape, but that the rays, whether direct or reflected, are of use only as they impel the particles of fire in parallel directions: that parallelism being destroyed, by intercepting the solar rays, the fire instantly assumes its natural state of uniform diffusion.

M. de Luc, in his *Lettres Physiques*, is of opinion, that the solar rays are the principal cause of heat; but that they only heat such bodies as do not allow them a free passage. In this respect he agrees with Newton; but then he differs totally from him concerning the nature of the rays of the sun. He does not admit the emanations of any luminous corpuscles from the sun, or rather self-shining substances, but supposes all space to be filled with an ether of great elasticity and small density, and that light consists in the vibrations of this ether, as sound consists in the vibrations of the air. Upon Newton's supposition, says an excellent writer, the causes by which particles of light, and the corpuscles constituting other bodies, are mutually attracted and repelled, is uncertain. The cause of the uniform diffusion of fire, by a series of vibrations, as already stated, is equally inexplicable; and we add to the other difficulties attending the supposition of an universal ether, by the want of a first mover to make the sun vibrate. See Light.

We do not in the present case propose, mathematically, investigating the doctrine of gravitation, or the motions of the heavenly bodies, but it will be necessary to premise, that there are two forces in continued operation, the one termed the *centripetal*, the other the *centrifugal*, the first tending to draw all bodies towards each other, while the second acts in precisely the opposite direction. This species of universal attraction, which was first examined by our own immortal Newton, and to which his attention was accidentally drawn by the fall of an apple from a tree, is but a branch of the same system of forces which holds all the bodies on the earth's surface together. Iron owes its tenacity to the attraction of cohesion, and it is a similar force which causes the drops of falling rain to be spherical. This fact has been beautifully illustrated by a modern poet—

> "That self-same law which moulds a tear,
> And bids it trickle from its source;
> That law preserves the earth a sphere,
> And guides the planets in their course."

The mutual attraction between the planets and the sun keeps them from flying off from their orbits by the centrifugal force, which is generated by their revolving in a curve; and the latter force again keeps them from falling into the sun, which would be the case, if it were not for the motion impressed upon them. Thus these two powers balance each other, and preserve order in the entire system.



This doctrine, which is founded on the demonstrations of Sir Isaac Newton, may be thus illustrated. If a planet, as our earth at *a*, gravitates, or is attracted towards the sun, *y*, so as to fall from *a* to *p*, in the time that the projectile force would have carried it from *a* to *x*, it will describe the curve *a u* by the combined action of these two forces, in the same time that the projectile force, singly, would have carried it from *a* to *x*, or the gravitating power, singly, have caused it to descend from *a* to *p*; and these two forces being duly proportioned, the planet obeying them both, will move in the circle *a u b c*. But, if whilst the projectile force would carry the planet from *a* to *v*, the sun's attraction should bring it down from *a* to *f*, the gravitating power would then be too strong for the projectile force, and would cause the planet to describe the curve *a c*. When the planet comes to *c*, the gravitating power (which always increases as the square of the distance from the sun, *y*, diminishes) will be yet stronger, for the projectile force, and by conspiring, in some degree, therewith, will accelerate the planet's motion all the way from *c* to *g*, causing it to describe the arcs *a a d e f*, &c., all in equal times. Having its motion thus accelerated, it thereby acquires so much centrifugal force, or tendency to fly off at *g*, in the line *g h*, as overcomes the sun's attraction; and the centrifugal force being too great to allow the planet to be brought nearer to the sun, or even to move round him in the circle *k l m*, &c. it goes off, and ascends in the curve *g j o q*, &c., its motion decreasing as gradually from *g* to *a* as it increased from *a* to *g*, because the sun's attraction now acts against the planet's projectile motion just as much as it acted with it before. When the planet has got round to *a*, its projectile force is as much diminished from its mean state as it was augmented at *g*; and thus the sun's attraction being more than sufficient to keep the planet from going off at *a*, it describes the same orbit over again by the virtue of the same forces or powers. A double projectile force will always balance a quadruple power of gravity. Let the planet at *a* have twice as great an impulse from thence towards *x* as it had before; that is, the same length of time that it was projected from *a* to *v*, as in the last example; let it now be projected from *a* to *w*, and it will require four times as much gravity to retain it in its orbit; that is, it must fall as far from *a* to *r* in the time that the projectile force would carry it from *a* to *c*, otherwise it would not describe the curve *a t*, as is evident from

the figure. But in as much as the planet moves from a to c, in the higher part of its orbit, it moves from f to g, or from g to j, in the lower part thereof; because from the joint action of these two forces, it must always describe equal areas in equal times throughout its annual course. These areas are represented by the triangles $a\ y\ c$, &c., whose contents are equal to one another from the properties of the ellipse.

The *Earth* we inhabit must now be examined; its motions with reference to the occurrence of day and night, the phenomena of the seasons, &c., will readily be understood. Its mean distance from the sun is 23984 times its own semi-diameter; so that it is nearly 95 millions of miles distant from that luminary. It performs its mean sidereal revolution in 365.2563612 mean solar days, or 365 days, 6 hours, 9 minutes, 9 seconds, 6: but the time employed in going from one equinox to the same again, or from one tropic to the same again (whence called the tropical revolution), is only 365.2422414 mean solar days, or 365 days, 5 hours, 48 minutes, 49 seconds, 7.

The axis of the earth is inclined to the pole of the ecliptic, at an angle which, at the commencement of the present century, was 23° 27′ 56″ 5: which angle is called the obliquity of the ecliptic. It is observed to decrease at the rate of 0″, 4755 in a year. But this variation is confined within certain limits, and cannot exceed 2° 42′.

This angle is also subject to a periodical change, called the nutation; depending principally on the place of the moon's node: whereby the axis of the earth appears to describe a small ellipse in the heavens.

The intersection of the equator with the ecliptic is not always in the same point; but is constantly retrograding or receding contrary to the order of the signs. Consequently the equinoctial points appear to move forward on the ecliptic; and whence this phenomenon is called the precession of the equinoxes. The quantity of this annual change, caused by the action of the sun and moon, and which is called the luni-solar precession, is 50″.41; from which we must deduct the direct motion caused by the planets, equal to 0″.31: and the difference, or 50″.10 is the general precession in longitude. It is subject to a small secular variation. A complete revolution of the equinoxes is performed in 25.868 years.

A mean solar day, as adopted by the public in this country, is the time employed by the earth in revolving on its axis, as compared with the sun, supposed to move at a mean rate in its orbit, and to make 365.2425 revolutions in a mean Gregorian year. But the mean solar day, adopted by astronomers, is founded on the assumption that the sun makes only 365.2422414 revolutions in a mean Gregorian year. It is divided into 24 mean solar hours; and these are again subdivided into mean solar minutes and seconds.

The apparent day is the time employed by the earth in revolving on its axis, as compared with the apparent place of the sun. This day is also divided into 24 apparent hours; which are again subdivided into apparent minutes and seconds. This mode of reckoning is still used by the public in many parts on the continent; and is frequently referred to by the practical astronomer on various occasions. In fact, the apparent culmination of the sun is the commencement of the astronomical day to every practical astronomer; and in most ephemerides the computations are made in apparent time.

The astronomical year is divided into four parts, determined by the two equinoxes and the two solstices. The interval between the vernal and autumnal equinoxes is (on account of the eccentricity of the earth's orbit, and its unequal velocity therein) nearly eight days longer than the interval between the autumnal and vernal equinoxes. These intervals were, in 1801, nearly as follow:—

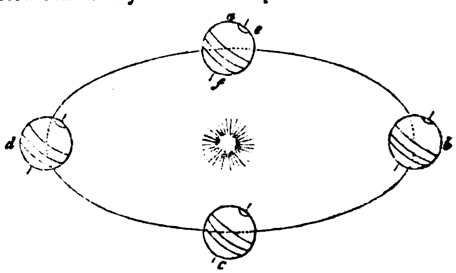
	D.	H.	M.	D.	H.	M.
From the vernal equinox to the summer solstice	= 92	21	50	= 186	11	34
From the summer solstice to the autumnal equinox	= 93	13	44			
From the autumnal equinox to the winter solstice	= 89	16	44	= 178	18	17
From the winter solstice to the vernal equinox	= 89	1	33			
				7	17	17

The figure of the Earth is that of an oblate spheriod; the axis of the poles being to the diameter of the equator as 304 to 305.

The mean diameter of the Earth is about 7916 miles: its equatorial diameter is 7924 miles, and its polar diameter 7898 miles.

As a necessary consequence from this circumstance, the degrees of latitude increase in length as we recede from the equator to the poles. But different meridians under the same latitude present different results; the general fact however is well ascertained.

The peculiar phenomena of the *seasons*, to which we may now call the reader's attention, are occasioned by the annual motion of the earth in its orbit. To understand this, we must bear in mind that the axis of the earth is inclined to the plane of its orbit, and that it always keeps parallel to itself, or is directed constantly to the same point of the heavens.

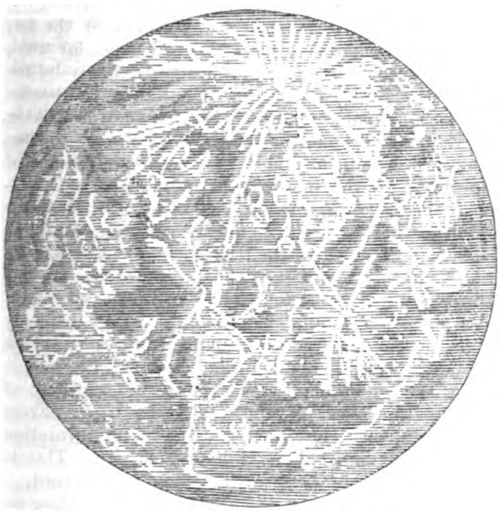


Let the accompanying figure represent the earth in different parts of its elliptic orbit. In the spring, the circle which separates the light from the dark side of the globe, called the terminator, passes through the poles, as appears in the position a. The earth, then, in its diurnal rotation about its axis, has every part of its surface as long in light as in shade; therefore the days are equal to the nights all over the world; the sun being at that time vertical to the equatorial parts of the earth. As the earth proceeds in its orbit, and comes into the position b, the sun becomes vertical to those parts of the earth under the tropic, and the inhabitants of the northern hemisphere will enjoy summer on account of the solar rays falling more perpendicularly

upon them; they will also have their days longer than their nights, in proportion as they are more distant from the equator; and those within the polar circle will have constant daylight. At the same time the inhabitants of the southern hemisphere have winter, their days being shorter than their nights, in proportion as they are farther from the equator; and the inhabitants of the polar regions will have constant night. The earth then continues its course to the position c, when the terminator again passes through the poles, and the days and nights are equal. After this the earth advances to the position *d*, at which time the inhabitants of the northern hemisphere have winter, and their days are shorter than their nights.

In summer, when the earth is at *b*, the sun is farther from it than in winter, and in fact, the disc of the sun appears longer in the winter than in the summer. The difference of heat is not owing to the sun's being nearer to us, or more remote, but to the degree of obliquity with which its rays strike any part of the earth. (See Heat and Sun.)

The *moon* is the constant attendant of the earth, and revolves around it in 27 days, 7 hours; but the period from one new or full moon to another, is about 29 days 12 hours. She is the nearest of all the heavenly bodies; being only about two hundred and forty thousand miles distant from the earth. She is much smaller than the earth; being only about 2160 miles in diameter.

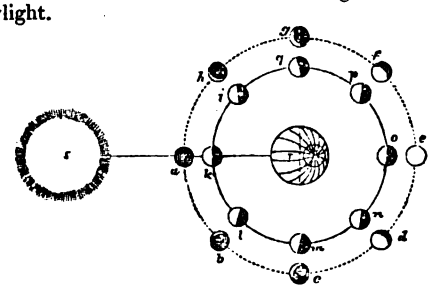


The surface of the moon when viewed with a telescope, presents an interesting and variegated aspect; being diversified with mountains, valleys, rocks, and plains, in every variety of form and position. Some of these mountains form long and elevated ridges, resembling the chains of the Alps and the Andes; while a variety of others, of a conical form, rise to a great height, from the middle of level plains, somewhat resembling the Peak of Teneriff. But the most singular feature of the moon is, those circular ridges and cavities which diversify every portion of her surface. A range of mountains of a circular form, rising three or four miles above the level of the adjacent districts, surrounds, like a mighty rampart, an extensive plain; and, in the middle of this plain or cavity, an insulated conical hill rises to a considerable elevation. Several scores of these circular plains, most of which are considerably below the level of the surrounding country, may be perceived with a good telescope, on every region of the lunar surface.

The preceding view of the moon's disc is taken from Russel's great map, and will furnish a tolerable notion of its rugged and unequal surface as seen through a telescope.

By the observations made by Dr. Herschel, in November, 1779, and the four following months, we learn that the altitude of the lunar mountains has been very much exaggerated. His observations were made with great caution, by means of a Newtonian reflector, 6 feet 8 inches long, and with a magnifying power of 222 times, determined by experiment; and the method which he made use of to ascertain the altitude of those mountains, which during that time he had an opportunity of examining, seems liable to no objection. The rock situated near *Lacus Niger*, was found to be about one mile in height, but none of the other mountains, which he measured, proved to be more than half of that altitude; and Dr. Herschel concludes that, with a very few exceptions, the generality of the lunar mountains do not exceed half a mile in their perpendicular elevation.

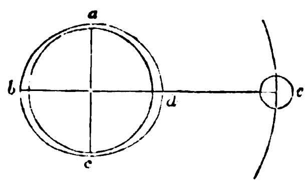
To Dr. Herschel we are also indebted for an account of several burning volcanoes, which he saw at different times in the moon. In the 77th vol. of the *Phil. Trans.* he says, "I perceive three volcanoes in different places of the dark part of the new moon. Two of them are nearly extinct; or, otherwise in a state of going to break out. The third showed an actual eruption of fire, or of luminous matter." On the next night, Dr. Herschel saw the volcano burn with greater violence than on the preceding evening. He considered the eruption as resembling a small piece of burning charcoal when it is covered by a thin coat of white ashes, which frequently adhere to it, when it has been some time ignited, and it had a degree of brightness, about as strong as that with which such a coal would be seen to glow in faint daylight.



The phases of the moon, as they appear at eight different points of her orbit, are represented in the accompanying figure, where *s* represents the sun, the earth being in the centre, and *a b c*, &c., the moon's orbit. When the moon is at *k*, in conjunction with the sun, her dark side being entirely towards the earth, she will be invisible, as at *a*, and is then called the new moon. When she comes to her first octant at *i*, a quarter of her enlightened hemisphere will be turned towards the earth, and she will then appear horned, as at *h*. When she has run through the quarter of her orbit, and arrived at *q*, she shows us the half of her enlightened hemisphere, as at *g*, when it is said she is one half full. At *p* she is in her second octant, and by showing us more of her enlight-

ened hemisphere than at *g*, she appears gibbous. At her opposition at *o*, her whole enlightened side is turned towards the earth, when she appears round as at *e*, and she is said to be full; having increased all the way round. On the other side she decreases again all the way from *e* to *a*; thus, in her third octant, part of her dark side being turned towards the earth, she again appears gibbous. At *m* she appears still farther decreased, showing again exactly one-half of her illuminated side. But when she comes to her fourth octant, she presents only a quarter of her enlightened hemisphere, and again appears horned. And at *a*, having now completed her course, she again disappears, and becomes a new moon again, as at first.

The *Tides* form an exceedingly interesting part of the subject of physical astronomy. The ocean covers more than half the globe; and this large body of water is in continual motion, ebbing and flowing alternately, that is, if the tide be supposed at high water mark, it will, after a short period, subside, and flow back for about six hours, when it will be at low water mark. The time of high water, however, is not always the same, but is about three-quarters of an hour later each succeeding day, for near thirty days, when it begins as before. Thus we may suppose at a certain place, it is high water at three o'clock in the afternoon on the day of new moon; the next day it will be high water at three-quarters of an hour after three, the day following at half-past four, and so on till the next new moon, when it will be again high water at three. This answers to the motion of the moon; for she rises every day about three-quarters of an hour later than the preceding one; and thus completes her revolution round the earth in about thirty days.



According to the Newtonian principle of attraction, these phenomena are thus explained. The waters at *d*, on the side of the earth next the moon *e*, are more attracted than the central parts *a c*, and these again move more than the waters on the opposite side at *b*, therefore the distance between the earth's centre and the waters on its surface under and opposite the moon will be increased. To explain this more fully, it should be borne in mind, that though the earth's diameter bears a considerable proportion to its distance from the moon, yet this diameter is nothing when compared to the earth's distance from the sun, consequently the difference of the sun's attraction on the sides of the earth opposite to him will be far less than the difference of the moon's attraction on the sides opposite to her; therefore the moon must raise the tides higher than they could be by the sun. Sir Isaac Newton has determined that the influence of the sun in this case is three times less than that of the moon. The tides, then, are properly the joint production of the sun and moon; or, in fact, there are two tides, a solar and a lunar, whose effects are joint or opposite, according to the situation of the bodies by which they are affected. When the sun and moon act together, as at new and full moon, the flux and reflux become considerable; and are called spring tides. But when one tends to elevate the waters, and the other to depress them, as at the moon's first and third quarters, then the flux and reflux will be diminished; these are called neap tides.

The sun being farther from our hemisphere in March and September, than in February and October, is the cause why the greatest tides happen a little before the vernal, and a little after the autumnal equinox.

When the moon is in the equator, the tides are equally high in both parts of the lunar day; but as she declines towards either pole, the tides are alternately higher or lower in northern or southern latitudes. The tides are so retarded in their passage through channels, and so affected by capes and headlands, as to happen variously at different places. The tide raised in the German Ocean, when the moon is three hours past the meridian, takes three hours to arrive at London Bridge. Lakes have no tides, because every part is attracted alike. The Mediterranean and Baltic seas have but small elevations on account of the narrowness of the inlets by which they communicate with the ocean.

Having examined the phenomena of the tides in connection with the attractive influence of the moon, it will now be advisable to observe the effects of that body when its orbit or path brings it between our planet and the sun, or vice versa, in which case an *eclipse* is produced.

Eclipses, especially of the sun, have always been considered as events of the most portentous kind. Isaiah, and others of the sacred writers, speak of them as indicative of the wrath of the Almighty. Homer, Pindar, Pliny, and many others of the ancients, also make mention of them in a similar way; and it is used to be noticed, more particularly by the superstitious, that an eclipse was often accompanied by a national calamity, or an occurrence of a striking nature, the malevolent effects of which were to continue, for the sun, as many years as the eclipse lasted hours, and for the moon as many months. Dionysius of Halicarnassus remarks, that both at the birth and death of Romulus there was a total eclipse of the sun, during which the darkness was as great as at midnight. It is also said that there was a solar eclipse on the day the foundation of Rome was laid.

An eclipse of the moon is mentioned by Ptolemy to have been observed by the Chaldeans at Babylon 720 years before the birth of our Saviour; the middle of the eclipse reducing the time to the meridian of Paris, was 6 hours, 48 minutes, March 19th. From this eclipse it is determined that the mean revolution of the moon is 27 days, 7 hours, 43′ 5″. This is considered the first eclipse of the moon on record.

Thales rendered himself famous by foretelling an eclipse of the sun; he, however, only predicted the year in which it would happen, and this he was probably enabled to do by the Chaldean Saros, a period of 223 lunations. This eclipse is rendered remarkable by its happening just as the armies under Alyattes, king of Lydia, and Cyaxeres the Mede, were engaged; and being regarded by each party as an evil omen, inclined both to make peace: it has been clearly proved that this eclipse occurred 610 years before Christ, September 30. Xenophon observes, that the king of the Persians laid siege to the city of Larissa at the time the empire was taken from the Medes, but was not able by any means to make himself master of it; finally, a cloud coming over the sun made it disappear, so that the hearts of the inhabitants failed, and the city was taken. This cloud

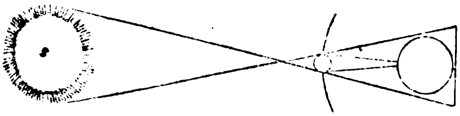
was, no doubt, the moon eclipsing the sun; for it appears that Cyrus finished the reduction of the Median empire, B.C. 547, in which year there was a great solar eclipse, the centre of which crossed the Tigris, not far from the place where Larissa was situated.

It is by a lunar eclipse that a mistake has been found in the Christian era; for it is well known that Christ was born when Herod was king of Judea; and Josephus affirms, that just before the death of this Herod there was an eclipse of the moon on the night between the 12th and 13th of March: but it has been clearly proved that this eclipse happened on the fourth year before what is considered the Christian era; wherefore this era ought to be carried back three years at least. The darkness that occurred at our Saviour's crucifixion, and which continued three hours, cannot be attributed to an eclipse of the sun, the Passover being kept at the time of full moon: had even the two luminaries been in conjunction, the darkness could only have lasted four or five minutes, owing to their apparent diameters being so nearly equal. Dionysius, a judge of Areopagus, being at Heliopolis, and observing this preternatural phenomenon, cried out, that "Nature was either dissolving, or the God of nature suffering." He afterwards embraced the Christian faith, and suffered martyrdom for the truth of it.

In China there is a tribunal of astronomy, the business of which is to calculate eclipses, and to present their types to the emperor and mandarins some months before they occur, with an account of the part of the heavens where they will happen, and how many digits the luminary will be eclipsed. When an eclipse is announced, preparation is made at court for the observance of it; as soon as it begins, a *blind man* beats a drum, upon which the mandarins and great officers mount their horses, and assemble in the great square of the palace.

An eclipse happened during Lord Macartney's embassy to China, which kept the emperor and his mandarins the whole day devoutly praying the gods that the moon might not be eaten up by the great dragon which was hovering about her: the next day a pantomime was performed, exhibiting the battle of the dragon and the moon, and in which two or three hundred priests, bearing lanterns at the end of long sticks, dancing and capering about, sometimes over the plain, and then over chairs and tables, bore no mean part.

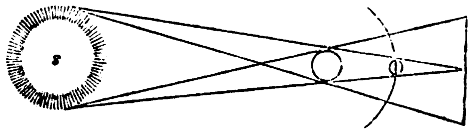
From this brief view of the early history of eclipses, we may now by the aid of an engraving illustrate the cause of these singular phenomena.



The sun at *s* is seen to have its light intercepted in its passage to the larger circle, on the right side of the figure by the moon's disc, which falls intermediate to those bodies. Now, in consequence of this arrangement of the sun, earth, and moon, an eclipse must occur. If the orbit of the moon was parallel to that of the earth, this exclusion of the sun's rays would happen on each succeeding month; but as her nodes are continually changing, annular eclipses of the sun which really arise from the moon, are of comparatively rare occurrence.

An annular eclipse is *central*, but not *total*; for the moon being at this time in her *apogee*, or at her greatest distance from the earth, her shadow terminates at some distance from its surface. Even when nearest to the earth, or in her *perigee*, her shadow never falls upon more than 180 miles of the surface. During total eclipses of the sun, small stars become visible; and at the period of the great solar eclipse in 1820, at which time 10½ digits out of the 12 were obscured, the planets Mercury and Venus could be seen by the naked eye.

By a reference to the engraving, it will be seen that an eclipse of the sun can only last for a short time, as the penumbra or shadow projected on the earth is smaller than the moon itself; but in the next form of eclipse, for which we shall require another figure, the darkness may last for a much longer period.



The sun is still in the same situation as before, but the earth and moon have changed places, so that an inhabitant of the latter body would see the earth obscuring the sun's rays. It will thus be obvious, that what we call an eclipse of the moon, is in reality an eclipse of the solar light.

A total eclipse of the moon can only happen when that body is exactly in the node at the time of opposition, in which case it remains enveloped in the shadow of the earth two hours; and as it passes through the centre of the shadow, which is considerably darker than near the edges, the moon is more completely obscured.

A great solar eclipse, visible in England, will take place 15th May, 1836, when 11° 18′ will be covered.

Another considerable eclipse of the sun will occur 15th March, 1858, when 11° 30′ will be hidden.

A still more remarkable eclipse of the sun will take place 19th August, 1887, when the whole of the disc will be covered excepting 2′.

A total eclipse, without continuance, will occur 3d February, 1916. The apparent diameters will coincide, and for an instant there will be a total concealment of the sun's light. This eclipse will be the greatest that will be visible in England till after the year of our Lord 2000.

To complete the above view of the solar system, it will be necessary now to examine another class of bodies, differing very considerably in their arrangement from the planets. These are the *comets*; they generally appear attended by a nebulous light, either surrounding them as a comma, or stretched out to a considerable length as a tail; and they sometimes seem to consist of such light only. Their orbits are so eccentric, that in their remoter situations, the comets are no longer visible to us, although at other times they approach much nearer to the sun than any of the planets; for the comet of 1680, when in its perihelion, was at the distance of only one-sixth of the sun's diameter from its surface. Their tails are often of great extent, appearing as a faint light, directed always towards a point nearly opposite to the sun: it is quite uncertain of what substance they consist; and it is difficult to determine which of the

conjectures respecting them can be considered as the least improbable: it is possible that, on account of the intense cold to which the comets are subjected in the greatest part of their revolutions, some substances, more light than any thing we can imagine on the earth, may be retained by them in a liquid, or even in a solid form, until they are disengaged by the effect of the sun's heat. But we are still equally at a loss to explain the rapidity of their ascent; for the buoyancy of the sun's atmosphere cannot possibly be supposed to be adequate to the effect; and on the whole, there is, perhaps, reason to believe that the appearances are derived from some cause bearing a considerable analogy to the fluid supposed to be concerned in the effects of electricity. It is probable that the density of the nucleus, or the body of the comet itself, is comparatively small, and its attraction for the tail consequently weak, so that it has little tendency to reduce the tail, even if it consists of a material substance, to a spherical form; for since some comets have no visible nucleus at all, there is no difficulty in supposing the nucleus, when present, to be of a very moderate density, and perhaps to consist of the same kind of substance as constitutes the tail, or comma, in a state of somewhat greater condensation. If, therefore, it should ever happen to a planet to fall exactly in the way of a comet, of which there is but very little probability, it is to be supposed that the inconvenience suffered by the inhabitants of the planet might be merely temporary and local: the chances are, however, much greater, that a comet might interfere in such a manner with a planet, as to deflect it a little from its course, and retire again without coming actually into contact with it.

The number of comets is very much greater than that of the planets which move in the vicinity of the sun. From the reports of former historians, as well as from the observations of late years, it is ascertained that more than four hundred and fifty have been seen previous to the year 1771; and when the attention of astronomers was called to this subject, by the expectation of the return of the comet of 1759, no fewer than seven were observed in the course of as many years. From this circumstance, and the probability that all the comets recorded in ancient authors, were of considerable apparent magnitude, while the smaller were overlooked; it is reasonable to conclude that the number of comets is considerably beyond any estimate that might be made from the observations we now possess. But the number of comets whose orbits are settled with sufficient accuracy to ascertain their identity when they may appear again, is no more than fifty-nine, reckoning as late as the year 1771. The orbits of most of these are inclined to the plane of the ecliptic in large angles, and the greater number of them approached nearer the sun than the earth ever does. Their motions in the heavens are not at all in the order of the signs, or direct, like those of the planets; but the number whose motion is retrograde, is nearly equal to that of those whose motion is direct.

The analogy between the periodical time of the planets, and their distances from the sun, discovered by Kepler, takes place also in the comets. Hence, the mean distance of a comet from the sun may be found by comparing its period with the time of the earth's revolution round the sun: thus, the period of the comet that appeared in 1531, 1607, 1682, and 1759, being about seventy-six years, its mean distance is found by this proportion: as the square of one year, the earth's periodical time, is to 5776 the square of 76, the comet's periodical time; so is 1,000,000 the cube of 100, the earth's mean distance from the sun, to 5,776,000,000 the cube of the comet's mean distance, the cube root of which is 1794, the mean distance itself, in such parts as the mean distance of the earth contains 100. If the perihelion distance of this comet, 58, be taken from 3588, double the mean distance, we shall have the aphelion distance 3530 of such parts as the distance of the earth contains 100; and this is little more than 35 times the distance of the earth from the sun. By a like method, the aphelion distance of the comet of 1680, comes out 138 times the mean distance of the earth from the sun, supposing its period to be 575 years; so that this comet in its aphelion, goes to more than 14 times the distance from the sun that Saturn does.

Comets, in describing their elliptic orbits round the sun, have been found to be disturbed by the action of the larger planets, Jupiter and Saturn; but the great eccentricity of their orbits makes it impossible, in the present state of mathematical science, to assign the quantity of that disturbance for an indefinite number of revolutions, though it may be done for a limited portion of time, by considering the orbit as an ellipsis, the elements of which are continually changing. This method was suggested by La Grange, and is followed in the *Mécanique Céleste*. Dr. Halley, when he predicted the return of the comet of 1682, took into consideration the action of Jupiter, and concluded that it would increase the periodic time of the comet a little more than a year; he therefore fixed the time of the reappearance to the end of the year 1758, or the beginning of 1759. He professed, however, to have made this calculation hastily, or, as he expresses it, *levi calamo*.—(*Synopsis of the Astronomy of Comets.*)

The effects both of Jupiter and Saturn, on the return of the same comet, were afterwards calculated more accurately by Clairaut, who found that it would be retarded 511 days by the action of the former planet, and 100 by the action of the latter; in consequence of which, the return of the comet to its perihelion would be on the 15th of April, 1759. He admitted, at the same time, that he might be out a month in his calculation. The comet actually reached its perihelion on the 13th of March, just thirty-three days earlier than was predicted; affording, in this way, a very striking verification of the theory of gravity, and the calculation of disturbing forces. The same comet may be expected again about the year 1835.

In some instances, the effects which the planets produce on the motion of comets, are far more considerable than in this example. A comet which was observed in 1770, had a motion which could not be reconciled to a parabolic orbit; but which could be represented by an elliptic orbit of no great eccentricity, in which it revolved in the space of five years and eight months. This comet, however, which had never been seen in any previous revolution, has not been seen in any subsequent one. On tracing the path of this comet, Mr. Burkhardt found that, between the years 1767 and 1770, it had come very near to Jupiter, and had done so again in 1779. He therefore conjectured that the action of Jupiter may have so altered the original orbit, as to render the comet for a time visible from the earth; and that the

same cause may have so changed it, after one revolution, as to restore the comet to the same region in which it had formerly moved. This, if a true conjecture, is the greatest instance of disturbance which has yet been discovered among the bodies of our system, and furnishes a very happy as well as an unexpected confirmation of the theory of gravity.

Though the comets are so much disturbed by the action of the planets, yet it does not appear that their re-action produces any sensible effect. The comet of 1770 came so near to the earth as to have its periodical return accelerated by two days; two hundred and forty-six, according to La Place; and if it had been equal in mass to the earth, it would have augmented the length of the year by not less than two hours and forty-eight minutes. It is certain that no such augmentation took place, and therefore that the disturbing force by which the comet diminished the gravity of the earth is insensible, and the mass of the comet, therefore, less than 1-500th of the mass of the earth. The same comet also passed through the middle of the satellites of Jupiter. Hence, it is reasonable to conclude, that no material, or even sensible alteration, has ever been produced in our system by the action of a comet.

M. Fatio has suggested that some of the comets have their nodes so very near the annual orbit of the earth, that if the earth should happen to be found in that part next the node, at the time of a comet's passing by, as the apparent motion of the comet will be incredibly swift, so its parallax will become very sensible; and the proportion thereof to that of the sun may be given; so that such transits of comets will afford the best means of determining the distance of the earth and sun.

The only other comet which it will be advisable to notice in our present article is that of Biela, the one which is now (November, 1832) generally expected. Lord Byron, whose writings bespeak more of true poetry than scientific knowledge, characterises one of these "wandering planets" as

> "A *pathless* comet and a curse,
> The menace of the universe."

We mention the singular mistake implied in the above line, as a similar one has been committed by many others as well as the noble poet. Now a reference to the comet of Biela will show that the path and period of a comet may be calculated on with great precision. It was particularly noticed by the astronomer from whom it takes its name, on the 27th of February, 1826, and on examining its elements in connection with the preceding comet, it was found that they must be one and the same. An anomaly however appeared in the period of revolution, which in one of its returns was completed in 2460 days, and in the other, 2469 days; this inequality was found to be owing to the action of the planet Jupiter, near which it had passed.

Proceeding onward, to the more distant regions of space, we come to the *fixed stars*. Prior to a notice of their classification, however, a few preliminary remarks will best explain their nature and arrangement.

The fixed stars are farther distant from the earth than the farthest of the planets; as we frequently find the fixed stars hid behind the most distant of those bodies; and they are supposed to have no parallax, which the planets have. It is inferred that the fixed stars are greater than our earth; for if that was not the case, they could not be visible at such an immense distance.

It is evident, also, that the fixed stars shine with their own light; for they are much farther from the sun than the remotest planet, and appear much smaller; but since, notwithstanding this, they are found to shine much brighter than such planet, it is evident they cannot borrow their light from the same source.

Astronomers divide the heavens into three regions; a northern and a southern hemisphere, and the zodiac. Stars of various magnitudes are seen in all these regions, and are classed into what are called constellations, or systems of stars, according as they lie near one another, so as to occupy those spaces which the figures of different sorts of animals would take up, if they were delineated on what appears to be the concave surface of the heavens. Those stars which the ancients could not bring into any particular constellation, they called unformed stars, but most of these are comprehended in the new constellations of the moderns.

This mode of dividing the stars into different constellations, serves to arrange them in such a manner that any particular star may be readily found in the heavens by means of a celestial globe, on which the constellations are so delineated as to put the most remarkable stars into those parts of the figures which may be most easily pointed out. This may be illustrated by a reference to the classification already alluded to.

Constellations of the Zodiac.

Constellations.	No. of Stars.	Principal stars and their magnitudes.	
Aries	66		
Taurus	140	Aldebaran	1
Gemini	85	Castor 1, Pollux	2
Cancer	83		
Leo	95	Regulus	1
Virgo	110	Spica Virginis	1
Libra	51	Zubenich Meli	2
Scorpio	44	Antares	1
Sagittarius	69		
Capricornus	51		
Aquarius	108	Scheat	3
Pisces	112		

Constellations on the north side of the Zodiac.

Ursa Minor	24	Stella Polous	2
Ursa Major	87	Dubhe	1
Cassiopeia	55		
Perseus	59	Algenib	2
Auriga	56	Capella	1
Bootes	54	Arcturus	1
Draco	60	Rastaben	2
Cepheus	35	Alderamin	3
Canes Venatici, viz. Asterion and Chara	25		
Cor Caroli	3		
Triangulum	16		
Triangulum Minus	5		
Musca	6		
Lynx	44		
Leo Minor	24		
Coma Berenicis	40		
Camelopardalus	58		
Mons Mœnalus	11		
Corona Borealis	21		

Constellations.	No. of Stars.	Principal stars and their magnitudes.	
Serpens	50		
Scutum Sobieski	8		
Hercules, cum Ramo et Cerbero	113	Ras Algethi	3
Serpentarius sive Ophuichus	67	Ras Alhagus	2
Taurus Poniatowski	7		
Lyra	22	Vega	1
Vulpecula et Anser	37		
Sagitta	18		
Aquila	40	Altair	1
Delphinus	18		
Cygnus	73	Deneb Adige	1
Equulus	10		
Lacerta	16		
Pegasus	85	Markab	2
Andromeda	66	Almaach	2

Constellations on the south side of the Zodiac.

Phœnix	13		
Officina sculptoria	12		
Eridanus	76	Acherner	1
Hydrus	10		
Cetus	80	Menekar	2
Fornax Chemica	14		
Horologium	12		
Reticulus Rhomboidalis	10		
Xiphias	7		
Cela Praxitelis	16		
Lepus	19		
Columba Noachi	10		
Orion	78	Betelgeux	1
Argo Navis	50	Canopus	1
Canis Major	30	Sirius	1
Equuleus Pictorius	8		
Monoceros	31		
Canis Minor	14	Procyon	1
Chamaeleon	10		
Pyxis Nautica	4		
Piscis Volans	8		
Hydra	60	Cor Hydræ	1
Sextans	4		
Robur Carolinum	12		
Machina Pneumatica	3		
Crater	11	Alkes	3
Corvus	9	Algorab	3
Crux	6	Crucis	1
Musca	4		
Apus	11		
Circinus	4		
Centaurus	36		
Lupus	24		
Quadra Euclidis	12		
Triangulum Australe	5		
Ara	9		
Telescopium	9		
Corona Australis	12		
Pavo	14		
Indus	12		
icroscopium	10		
Octans Hadleianos	43		
Grus	14		
Toucan	9		
Piscis Australis	20	Tomachaut	

The stars vary very materially in their apparent magnitude and number at different periods of time.

The first new star that we have any good account of, was discovered by Cornelius Gemma, in 1572, in the chair of Cassiopeia. It surpassed Sirius in brightness and magnitude; and was seen for sixteen months successively. At first, it appeared larger than Jupiter, and then it gradually diminished both in magnitude and lustre, until 1573, when it became invisible.

On the 13th of August, 1596, David Fabricius observed the stella Mira, in the neck of the whale; which has since appeared and disappeared periodically.

In the year 1600, William Jansenius discovered a changeable star in the neck of the swan; which, in time became so small as to be thought to disappear entirely; till the year 1657, when it recovered its former lustre and magnitude.

In the year 1604, Kepler and several of his friends saw a new star near the heel of the right foot of Serpentarius, so bright, that it exceeded any thing they had ever seen before; and they state, that it was every moment changing into some of the colours of the rainbow, except when it was near the horizon, at which time it was generally white. It surpassed Jupiter in magnitude. It disappeared between October 1605, and the February following, and has not been seen since that time.

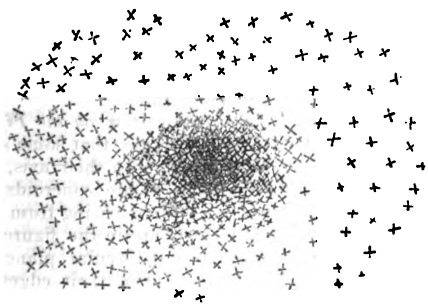
In July 1670, Hevelius discovered a new star, which was scarcely perceptible in October. In April following, it still retained its lustre, but wholly disappeared in August. In March 1672, it was seen again, but very small; and has not been visible since. It may be proper to add, that the star Algol, in the space of rather more than two days, changes from the second to the fourth magnitude.

M. Maupertuis, in his *Dissertation on the Figures of the Celestial Bodies*, is of opinion, that some stars, by their prodigious swift rotation on their axis, may not only assume the figures of oblate spheroids, but that by the great centrifugal force arising from such rotations, they may ultimately attain the figure of a mill-stone, or be reduced to flat circular planes, so thin, as to be quite invisible when their edges are turned towards us, as Saturn's ring is in such a position. But when very eccentric planets, or comets, go round any flat star in orbits much inclined to its equator, the attraction of the planets, or comets, in their perihelions must alter the inclination of the axis of the star; on which account it will appear more or less large and luminous, as its broad side is more or less towards us. And thus he imagines we may account for the apparent changes of magnitude and lustre of those stars, and likewise for their appearing and disappearing.

Dr. Herschel's success in examining the milky-way with his great instrument, induced him to turn his telescope to the nebulous parts of the heavens. Most of these yielded to a Newtonian reflector, of twenty feet focal distance, and twelve inches aperture; and he ascertained that they were composed of stars, or at least contained stars, and afforded very strong indications of their consisting of them entirely. "The nebulæ," says he, "are arranged into strata, and run on to a great length, and some of them I have been able to pursue, and to guess pretty well at their form and direction. It is probable enough that they may surround the whole starry sphere of the heavens, not unlike the milky-way, which undoubtedly is nothing but a stratum of fixed stars; and as this immense starry bed is not of equal lustre in every part, nor runs in one straight direc-

tion, but is curved, and even divided into two streams along a very considerable portion of it; we may likewise expect the greatest variety in the strata of the cluster of the stars and nebulæ. One of these nebulous beds is so rich, that in passing through a section of it in the time of only thirty-six minutes, I have detected no less than thirty-one nebulæ, all distinctly visible upon a fine blue sky. Their situation and shape, as well as condition, seem to denote the greatest variety imaginable. In another stratum, or perhaps a different branch of the former, I have often seen double and treble nebulæ variously arranged; large ones, with small seeming attendants; narrow, but much extended lucid nebulæ, or bright dashes; some of the shape of a fan, resembling an electric brush issuing from a lucid point; others of the cometic shape, with a seeming nucleus in the centre, or like cloudy stars, surrounded with a nebulous atmosphere; a different sort of orb again, containing a nebulosity of the milky kind, like those wonderful, inexplicable phenomena about Orionis; while others shine with a fainter mottled kind of light, which denotes their being resolvable into stars."

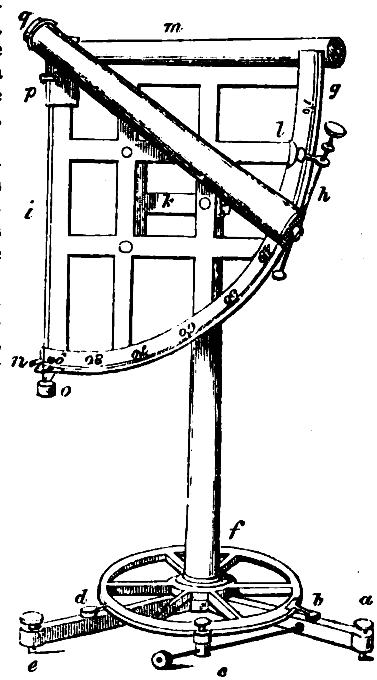
One of the remarkable nebulous appearances observed by Dr. Herschel, is delineated in the accompanying wood cut. It is taken from Orion, and does not of course come within the powers of a small telescope.



Huygens considered the view he had of this nebulosity as similar to that arising from a curtain being raised, and the observer piercing into an ocean of light, of which the waves were irregular.

The stars of the firmament are said to be fixed, because they have been generally observed to preserve the same distance from each other: they do not all appear to us of the same magnitude, whether they are really different in size one from the other, or whether they appear so to us in consequence of their different distances. It is probable that both these causes operate to display the fixed stars of such various magnitudes. Be this as it may, astronomers have agreed in distributing the fixed stars into six different classes, according to their relative magnitude, independent of those small stars which compose the white and brilliant spaces in the heavens, which are denominated nebulæ, and that bright band which extends across our hemisphere, and which from its lucid appearance is termed the milky-way. Those which are distinctly visible are fewer in number than might be supposed. The British catalogue, which, besides the stars visible to the naked eye, includes a great number which cannot be seen without the assistance of a telescope, contains no more than three thousand in both hemispheres. The number of stars discoverable, in either hemisphere, by the naked eye, is not above a thousand. From what we are able to judge by computation and observation, it is concluded that none of the fixed stars can be at a less distance than 32,000,000,000,000 of miles from us, which is farther than a cannon-ball would fly in 7,000,000 of years.

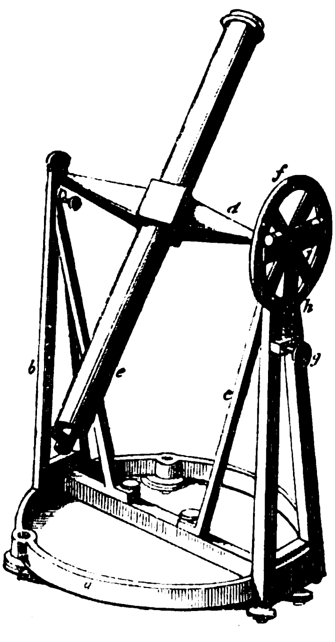
In pursuance of our plan as already arranged, we must now proceed to the subject of *practical astronomy*. Under this head it will be necessary in the first instance to describe the simplest sort of astronomical instruments, commencing with the *quadrant*.



This is a very important, and at the same time, a cheap piece of apparatus, though in large observatories it is but little employed. It is shown in the engraving, mounted on a circular pillar *f*, which is supported by a tripod, *a e*, resting on three foot-screws. The quadrant, *m*, the pillar, and the horizontal circle, all revolve round a vertical axis. A telescope is placed on the horizontal radius, and is directed to a meridian mark, previously made on some distant object for placing the plane of the instrument in the meridian, and also for setting the zero, or beginning of the scale, exactly horizontal. This is sometimes done by a level, instead of a telescope, and sometimes by a plumb-line, *i*, suspended from near the centre, and brought to bisect a fine dot made on the limb, where a microscope, *n*, is placed, to examine the bisection. The weight or plummet, at the end of the plumb-line, is suspended in a small cistern of water, *o*, which keeps it from being agitated by the air. A similar dot is made for the upper end of the plumb-line, upon a piece of brass, adjustable by a screw, *p*, in order that the line may be exactly at right angles with the telescope, when it is placed at 0°. The central part of the frame of the quadrant is screwed to a piece of brass, *k*, by three screws, and this piece is again screwed by three other screws at the top of the pillar, *f*. By means of the three first screws, the plane of the quadrant can be placed exactly parallel to the vertical axis, and by the other screws the telescope can be placed exactly perpendicular to it. The nut of the delicate screw, *h*, is attached by an universal joint to the end of the telescope. The collar for the other end is attached by a similar joint to a clamp, *l*, which can be fastened to any part of the limb. A similar

clamp-screw and slow motion is seen at *c*, for the lower circle.

In using this instrument, the axis of the telescope is adjusted to a horizontal line, and the plane of the quadrant to a vertical line, by the means already mentioned. The screw of the clamp, *l*, is then loosened, and the telescope directed to the star whose altitude is required. The clamp-screw being fixed, the observer looks through the telescope, and with the nut of the screw *h*, he brings the telescope into a position where the star is bisected by the intersection of the wires in the field of the telescope. The divisions are then to be read off upon the vernier, and the altitude of the star will be obtained. By means of the horizontal circle, *d*, *b*, all angles in the plane of the horizon may be accurately adjusted.



The *transit instrument* is of great use to the astronomical observer. It consists of a telescope, moveable in the plane of the meridian upon a horizontal axis, for the purpose of observing the precise instant when any celestial object passes the meridian.—One of Mr. Troughton's portable transit instruments is represented in the accompanying figure, where *e* is an achromatic telescope, firmly fixed by the middle to a doubly conical and horizontal axis, *d*, the pivots of which rest on angular bearings called Y's, at the top of the standards, *b*, *c*, rendered steady by oblique braces fastened to the central part of the circle *a*. The axis has two adjustments, one for making it exactly level, and the other for placing the telescope in the meridian. A graduated circle, *f*, is fixed to the extremity of the pivot which extends beyond one of the Y's, and the two radii that carry the verniers, are fitted to the extremity of the pivot in such a way as to turn round independent of the axis. The double verniers have a small level attached to them, and a third arm, *h*, which is connected with the standard by means of a screw, *g*. If the verniers are placed, by means of the level, in a true horizontal position, when the axis of the telescope is horizontal, and the arm *h* screwed to the standard, the verniers will always read off the inclination of the telescope, and will enable the observer to point it to any star, by means of its meridian altitude. The whole instrument rests on three foot-screws passing into the circle *a*. The telescope has a diagonal eye-piece for observing stars near the zenith, and in the field of view there are several parallel vertical wires crossed at right angles with a horizontal one.

In order to fix the transit instrument exactly in the meridian, the observatory clock should be previously regulated to sidereal time, by means of corresponding or equal altitudes of the sun or a star, taken before and after they pass the meridian, by small quadrants or circles, or by a good sextant. The axis of the transit is then to be placed horizontal, by means of a spirit level which accompanies the instrument, and the greatest care must be taken that the axis of vision describes in the heavens a great circle of the sphere.

The instruments we have now been describing, though of considerable value to the practical astronomer, are unfitted for some of the most important observations he will be called upon to make. On this account we proceed to describe a very important piece of apparatus, combining in itself a variety of instruments, and one that is well fitted for a private observatory.

When a simple telescope mounted on a stand, is elevated to view any heavenly body at the moment of its meridian passage, the observed body appears to pass horizontally across the field of view, but in any other situation to the east or west of the meridian, the apparent passage of the body through the field of view is in an oblique direction, and the more so the greater the declination towards the visible pole, and also the greater the distance from the meridian line. Hence, the motion of the simple telescope, which moves in a circle parallel to the horizon, when turned round on its vertical axis, will never coincide with the motion of a heavenly body that moves either in the equator, or in a circle parallel to it; unless indeed the observer could stand at one of the poles, in which case the equator would become the horizon, and circles of altitude would be also circles of declination. But no observer can be so circumstanced. He may, however, incline the axis of motion of his telescope, so as to be placed in the meridian, and exactly parallel to the earth's axis, and then when the field of view is directed to take in any heavenly body, the motion of the telescope round such axis, supposing it to be fixed, will attend the said body during the remainder of its path above the horizon. Accordingly we find Christopher Scheiner using a telescope mounted on a polar axis, in 1620, which was soon after the time that Galileo invented the simple dioptric telescope; and though Mullër contrived his torquet, a kind of portable equatorial, in 1544, yet the idea of Scheiner's polar axis most likely suggested to the modern instrument-makers the best principle on which an equatorial instrument, as well as the equatorial sector, ought to be constructed. By the use of Scheiner's contrivance, an observer could follow a star or other heavenly body through its diurnal arc, but it had no appendages to ascertain the place of the observed body, as to right ascension, declination, distance from the meridian, &c.; neither could the telescope be directed to a body invisible to the naked eyê.

Mr. Henry Hindley, an eminent clock-maker at York, was probably the first man who contrived and attached the different adjustable circles as companions to the telescope. Mr. Smeaton, in his paper on the *Graduation of Astronomical Instruments*, read before the Royal Society, November 17, 1785, states that Hindley contrived an instrument of the equatorial kind so early as 1741. This instrument had the equatorial plate, quadrant of latitude, and declination

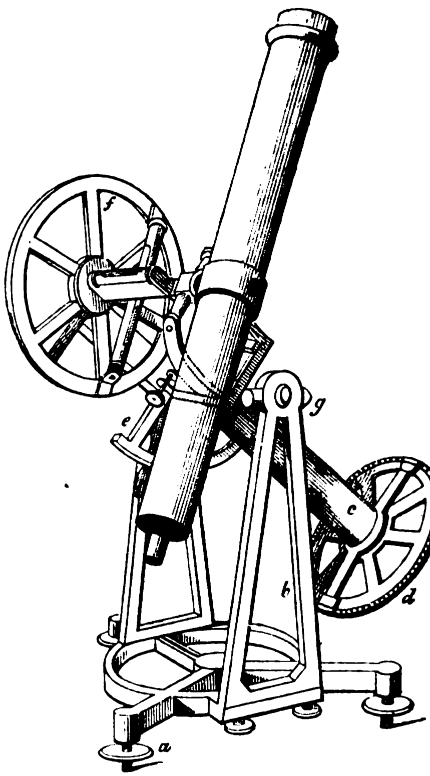
semi-circle indented at the circumference, and moved by worm-screws, containing fifteen threads each, all in action together.; which screws at the same time measured as micrometer screws, the angular motions. The telescope was of the refracting kind, and inverted the object viewed. "It staid with me," says Mr. Smeaton, "two years, in which time I showed it to all my mechanical and philosophical friends, amongst whom was Mr. Short, who afterwards published, in the *Philosophical Transactions*, an account of a portable observatory, but without claiming any particular merit for the contrivance."

Mr. Short placed his reflecting telescope over a system of graduated circles, and he has generally been considered as the first contriver of the equatorial instrument, though it appears evident from Mr. Smeaton's account that Hindley's instrument was somewhat prior to his.

We come now to Mr. Troughton, who constructed an equatorial instrument sufficiently large to be placed in an observatory for the purpose of making useful observations. This ingenious artist contrived many modifications of the instrument, but the portable equatorial instrument, invented by Mr. Fayrer, will require a more particular description, as its price will admit of its general use in private observatories. This instrument differs from its predecessors chiefly in these respects; it has no azimuth circle fixed in a permanently horizontal position; it has its equatorial circle divided into degrees and also into time, with two verniers reading at opposite points, one vernier reads to the accuracy of 30″ of space, and the other to 2″ of time; this circle has a long axis passing through a tube, so that it may be placed in a horizontal direction by its axis being placed firmly vertical, in which situation it becomes an azimuth circle; the telescope is fixed on the end of the axis of the declination circle. This position allows any elevation of the telescope that may be required, and keeps the observer's eye at a distance from the other parts of the instrument, but injures the uniformity of the appearance of the instrument as a whole; the levels are applied, one on the common axis of the telescope and declination circle, and the other at right angles thereto, as a chord to the declination circle; and lastly, the declination circle is complete, with opposite verniers reading to about twenty or thirty seconds, according to the dimensions of the graduated circles.

From such a construction it is easy to perceive that this little instrument possesses the advantage of having its telescope reversed as well as its circles, with respect to the opposite verniers, which property greatly ensures the accuracy of the adjustments. After these previous remarks, it will suffice to give a brief detail of the parts of this instrument, as represented in the accompanying figure.

The adjustment screws are shown at *a*. The triangular frames, *b*, are fixed firmly to the circular stand, and support the pivots of the horizontal axis, round which the tube *c* moves. At the summit of the triangular frame *b*, is an adjustable or sliding part, like that of a transit instrument, by which the telescope may be adjusted in the meridian, when previously placed nearly so by the feet. The graduated circle, which may be either an equatorial or azimuth circle, accordingly as it is inclined or vertical, has a steel axis nicely fitted to revolve in the tube in any required position with respect to the horizon; but the double vernier bar is in this case fast to the inferior end of the tube.



The posterior pivot of the horizontal axis, borne by the triangular bars, projects, and has firmly attached to it the quadrantal piece, *e*, partly hidden from sight in our view of the instrument; this quadrantal piece is graduated, and reads by a vernier as minutely as the other circles; it serves to set the equatorial axis parallel to the earth's axis, in which situation it may be clamped fast, as well as in a vertical, or indeed in any other position, by a clamping-screw out of sight in the present position, applying to the quadrantal arch; the declination circle is shewn at *f*, with its horizontal axis resting on a pair of vertical supports, carried by the upper end of the polar axis, that passes through the tube *c*, so that, when the telescope, attached to the axis of the declination circle, has any horizontal or rather oblique motion, the other circle moves with it, and indicates the distance moved along the equator, or in a circle parallel to it. The double vernier bar is on the posterior place of the declination circle, and may therefore be viewed after an observation without danger of altering the position of the telescope. The level on the declination axis may be conveniently adjusted by turning the circle half round, and by making the bubble keep the middle of the tube in both situations, which may be done, partly by the screws *a*, and partly by the screws of rectification of the level itself; and zero of the declination circle may be put to zero on the verniers when the circle is truly placed in an horizontal position, in which situation also zero of the quadrant *e*, must coincide with the zero on its vernier. An instrument thus constructed, will possess all the va-

rious powers ascribed to a portable equatorial, combined with the other instruments.

We have now to furnish an account of the most important astronomical instrument which the ingenuity and mechanical skill of this country has produced; we allude to the *great circle* of Mr. Ramsden, which has been very fully described by Piazzi. It is represented in our Plate, ASTRONOMY, *fig.* 1. The vertical axis of this instrument is composed of various parts, which revolve together, and which may be considered, when firmly united, as one piece; at the lower end is a cone, I, inverted, the smallest diameter of which is five inches, where it is attached to the azimuth or horizontal circle with a series of conical radii, and the greatest diameter is 14.2, where it is fixed to the oblong stage of brass, A; which stage is further strengthened by suspension pieces, at the four corners. The azimuth circle is three feet in diameter, divided into 180° twice over, and each of the degrees again into ten subdivisions of 6′ each. The extreme inferior end of the axis, below the azimuth circle, is a small cone of hard steel. On the stage A, are fastened four strong brass pillars, indicated by the letters C C C C, and placed near the corners of the stage. Above the superior ends of these four pillars, is another stage, B, of similar dimensions, in the centre of which is a tube, which constitutes the upper pivot of the axis; at each side of the central tube of this upper stage, is an opening which nearly divides the stage in two, except at the middle and two extreme edges, which edges are made firm by lateral connecting pieces; the use of the open parts of the upper stage is to admit the object end of the telescope, to view stars near the zenith.

The two large pillars, each 7 feet high, and 4 inches diameter, ascending from marble bases on the floor of the observatory, and terminating with a large arch, which connects their superior ends, constitute a part of the superior support of the vertical axis; two similar pillars, omitted in the engraving, also rest on the marble base at right angles to the above. At the top of the arches, a cross or piece of four straight bars, is screwed to the four upper portions of the arches, and a hole in the centre of this uppermost cross piece receives the tubular pivot of the vertical axis. The lower support of the vertical axis consists of three concentric circles of iron, laid one over another on friction rollers; the uppermost of which bears the inferior pivot of the axis, and the other two have each an adjustable motion, one from east to west, and the other from north to south. These are moved by handles attached to fine screws, which screws acting as pressing points, move the large iron circles in their respective directions, when the axis is to be placed exactly perpendicular to a horizontal line drawn in any azimuth. M is a mahogany circle attached to the uppermost iron circle; on this circle of wood is placed a balustrade of metal, R R, composed of a superior and inferior large ring, each being three feet in diameter, connected by twenty cylindrical pillars, each of one inch diameter, and 13 inches high; this balustrade defends the azimuth circle, and serves to give either a slow or quick motion from it to the axis of the instrument, by means of the clamping mechanism, connected with an universal joint, of which the handle Q only is seen in the figure. The microscopic micrometer, N, which reads off the graduations of the azimuth circle, is also carried between two of the pillars of this balustrade, together with the subjoined reflector of silver for the illumination of the dividing marks of the azimuth circle: the field of view of the compound microscope contains but a very small space of the image of the divided limb; it was therefore found necessary, not only to mark every degree with ten successive Arabic numerals, and also each tenth space, with larger numerals of the Roman character, but also to insert points for discriminating the ten subdividing lines, which are counted 0, 1, 2, 3, &c., the distance between each of which, we have already said is 6′, therefore, the corresponding values are 0′, 6′, 12′, 18′, 24′, &c. up to a degree, as read without the aid of the micrometer.

The compound microscope, N, has the mechanism of the micrometer, in the point where the focus of the eye-glass, or perhaps we should rather say, where the united foci of the glasses of the compound eye-piece meet the image of the subdivisions of the limb, as formed in the tube by the object-lens; this mechanism is rather complex, and cannot be very clearly apprehended, perhaps, by a mere verbal description; it consists of two parallel horizontal plates of metal, having each an oblong hole along its middle, the upper one of brass and the lower of steel; the brass one is divided into ten spaces of each 1′, counted each way from zero, which is a point in the middle, and is moveable separately by the horizontal screw on the left hand; the steel plate carries a cross hair or wire, and is adjustable to the right or left by a screw of 70 threads per inch, which has a nut, as a head, divided into 60 equal parts, one of which parts corresponds to a second of a degree; this divided head is placed at the right hand of the microscope, so that one of the two screws cannot be mistaken for the other, and both may be held at the same time, and turned by the separate hands of an observer, if necessary. To prevent a loss of motion in the screw of divided head, or micrometer-screw, a spring of contrary pressure is applied in constant action, which makes the cross wire move backwards or forwards, without the loss of even a second, as counted on the divided head.

The microscopes have two adjustments, one for the object-lens to make the image fall distinctly on the micrometer's thread and scale, and another for the eye-piece to render this image clear to the eye; also the micrometer has two adjustments, one to adjust zero of the scale, under the eye-piece, to zero of the image of the divided limb: these two latter adjustments are effected by the different fixing screws, which are not seen in the figure. The circumscribing boundary of the circle, corresponding to the felley of a wheel, is formed of two separate rings, united in various equidistant points by parallel cylindrical pieces, so that the appearance of the compound piece is that of a circular ladder; a form which gives strength without any great addition to the weight. On the plane of one of these rings is firmly fixed a third circle, which contains the lines of graduation, which are but faintly seen in the figure. The central piece, or nave of the wheel, into which the spokes, or radii, are fast, is a segment of a cylinder of cast brass, nicely perforated in the middle, and the spokes are composed of eight metallic cones and the telescope, which passes through the nave and forms two more. The horizontal axis of this large circle, or wheel, as we have described it, is formed of a double cone, which is hollow throughout, and has pivots of hard steel at the extreme ends; it has four supports,

ASTRONOMY.

Fig. 1.

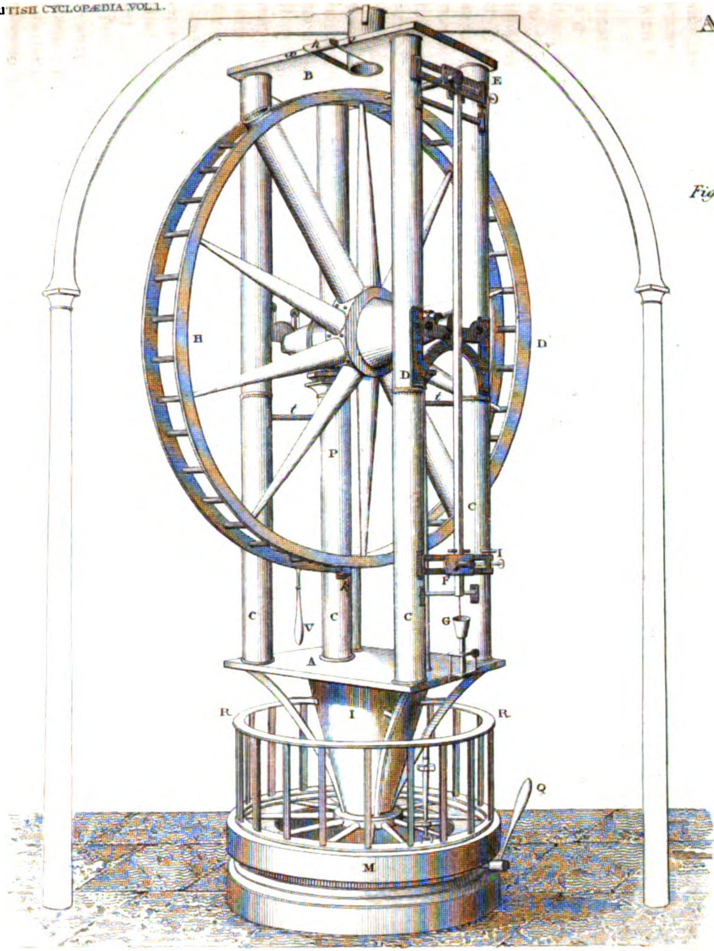
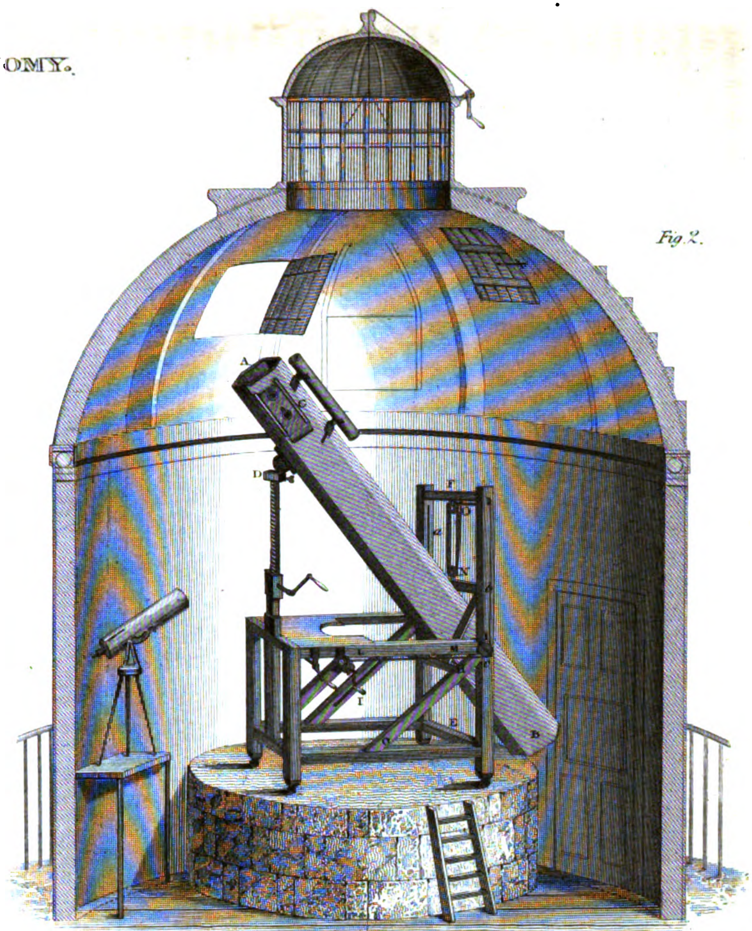


Fig. 2.



London Published by William Orr, Paternoster Row, January 1 1832.

from an idea that the weight would be too much for the pivots alone to bear. One of the supports is seen at D D, which is a kind of frame attached to the perpendicular pillars C C next to the eye; the extreme end of the axis *a*, which is not perforated, bears on a Y formed in the middle of the cross bar of this frame, which bar has an adjustable motion up and down, by means of the screw *p*, with a head divided into 50 parts, each of which parts corresponds to $\frac{3}{100}$ of an inch. Another support, every way similar to D D, is attached to the two upright pillars C C, behind the circle, which therefore cannot be seen, but it requires no farther description. The third and fourth supports of the axis are a fifth pillar, the top of which is seen through the arch of the frame D D, and its bottom near G, and a sixth pillar, P, opposite to the former. These two pillars placed nearer the middle of the stage A than the four corner pillars, C C C C, are each three feet and three inches high, and eleven inches distant from each other, measured from the interior sides we presume; they are made steady at their inferior ends, each by two cross bracing pieces, *t t*, fastened to the long pillars, C C and C C, respectively; one of which pieces, *t*, only can be seen attached to the right-hand supporting pillar, owing to the position of the figure. On the top of pillar P, may be seen a small frame, carrying a pair of friction rollers; which frame can be lowered or raised by a rod passing through the pillar down to below the stage A, under which is hidden from sight a screw of adjustment for the height of the said rod and frame of friction rollers. The rollers are placed edge to edge in the same plane, forming a kind of curved V between them, on which the projecting ring of the conical axis is supported. The situation of this ring piece, attached to the cone, is at the mean point, between the centre of the circle and the back steel pivot, which pivot is not seen in the figure. Thus one-half, or any smaller part of the weight of the circle may be made to bear on this support, by adjusting the screw of the long rod within the pillar, the nut of which we have said is under the stage A. Another support, with a frame of two friction rollers, exactly similar to the one described, is placed over the corresponding pillar, and under a corresponding annular piece embracing the second cone of the axis at its middle point; but the rod of this pillar, which adjusts the height and quantum of bearing of this second frame, does not descend so low as the stage A, but terminates a little below the middle of this pillar, which is cut into two, and joined again by a small frame of four little pillars near I, so that a hand may be put into the vacant space of the small frame, to adjust by a tapped nut acting here, instead of being put under the stage A; the reason of which is not quite evident from the appearance of the figure, nor is it explained in the original account. The end of the axis which is turned from view is perforated, and admits a lens that receives the light of a small lantern, H, placed in a line with it, and transmits this light, without the entrance of smoke or dust, to a diagonal mirror, which possesses a central hole in it, placed at the point of intersection of the telescope's line of sight, and of the central line of the axis: this mirror again reflects the received light towards the eye-piece of the telescope, and renders the two adjustable hairs, which cross one another at right angles in the united focus of the eye-glasses, distinctly visible to the eye of an observer on the darkest night.

It was found, however, that when much light was admitted into the telescope, the stars of small magnitude became invisible; on which account a contrivance was introduced for proportioning the quantity of light, according to circumstances. This contrivance consists of a parallelopiped composed of three pieces of glass, the middle one white, and the two extreme ones green, contained in a frame which has an adjustable motion by means of pulleys, two of which may be seen on the inside of the back pillars, C C, which pulleys assist the adjustment during the time of making an observation, if necessary, and limit the quantity of light, agreeably to the ascent and descent of the parallelopiped interposed between the lantern and the end of the axis. The reason of the green glasses being at both sides of the white glass, is, that the refraction of the light may be corrected by the second green glass, so as to prevent the wires in the focus of the eye-piece from appearing double. In this telescope there are six eye-pieces, five direct, and one diagonal, or what Piazzi calls prismatic, because the piece of glass that is placed at the elbow of a bent tube, put on as an eye-piece, is a prism bounded by one curved side and two rectilinear ones, the latter two of which are placed at an angle of 45°, with respect to each other; the curved side being that which first received the rays of light, and the diagonal ones being silvered. The peculiarity of this prismatic eye-piece is, that it inverts the object without reversing it; that is, the position is changed with respect to top and bottom, but not with respect to right and left. The prismatic eye-piece has two powers; one making the magnifying property of the telescope 75, and the other 130. The powers with the five direct eye-pieces are respectively 50, 75, 100, 130, and 170. The principal use of the prismatic powers is to search for stars and measure altitudes of bodies placed near the zenith; the above eye-piece with its additional tube being horizontal when the telescope is in a vertical position.

The vertical circle is graduated into 360° and figured into 90° four times over; each separate degree is also figured with Arabic numerals, and the subdivisions dotted or painted like the azimuth circle. The observed angle is read off by two different microscopes with micrometers, placed above and below the vertical circle, at the distance from each other of a semi-circle; the frame E of the superior microscope is attached to the nearest pillars, C C, as shown in the figure, just under the upper stage B, which frame contains sliding-pieces of adjustment for setting the microscope in the required position with respect to the divisions on the limb of the circle; the adjustments both of the microscope when placed, and also of its contained micrometer, are similar to those of the micrometer placed over the azimuth circle already described. The inferior microscope, F I, of the vertical circle is in every respect similar to the superior one, the micrometer's divided nut in both being placed to the right. The micrometers of these microscopes, however, have each two horizontal adjustments of motion, one parallel to the plane of the vertical circle, and the other perpendicular to that plane, and also each a vertical adjustment.

Besides these microscopes for reading off the subdivisions, each frame contains a smaller one, which we will call the secondary microscopes, the use of which is for viewing a fine plumb-line, suspended by a small screw over the superior frame E, and passing

down to G through a wooden square pipe, where the plumb may be seen immersed in the small vessel, G, full of water, above a small stage, in order to keep the line from oscillating. This vessel G may be raised or lowered by the screw that supports it. The secondary microscopes have each the same adjustments as the above-mentioned microscopes; and the plumb-line has also its point of suspension so adjustable, that it can be brought into the foci of the upper and lower eye-pieces so as to bisect the fields of view, when the microscopes are both properly adjusted.

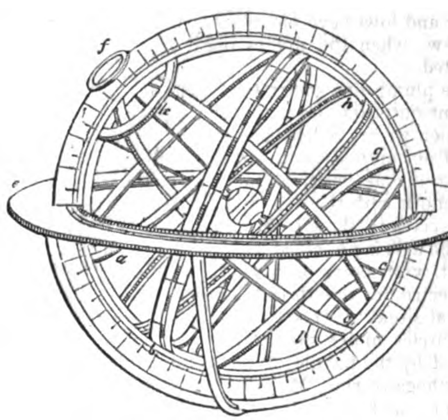
The plumb-line serves two separate, and very important purposes; for its peculiar application to both of which we are indebted to the ingenious Ramsden: first it not only serves to set the vertical axis perpendicular in one position, but by being carried round in azimuth with the axis and all the other appendages, serves to show if the perpendicular direction of the said axis is preserved with respect to all the points of east, west, north, and south; and if any deviation is detected by the thread being at one side of the original situation, then one of the adjustments of the iron circles under the inferior pivot of the axis, as effected by the handle of the compound-joint under the mahogany ring, M, must be made to verify the position; and, secondly, the horizontal axis of the vertical circle is made perfectly level by the same plumb-line; this is effected by an additional apparatus, in a very ingenious, as well as very accurate manner, which may be thus explained without a figure: suppose a bar of metal to be made of such length as, when used as a horizontal measure, would just reach from the divided face of the vertical circle to a point directly opposite it in one of the pillars at the upper end; and suppose again, this measuring bar to be applied below to a point at the lower part of the said pillar, to try if in this situation it will also touch the graduated face of the same circle; then, if the distance is found to be precisely the same in both cases, the conclusion would be from such a rough measure, that the pillar and the plane of the vertical circle are parallel, or very nearly parallel, to each other; now, as the circle was originally made by being turned on its own pivots in a large frame, its axis is necessarily at right angles to its plane, and consequently also to the surface of the pillar. Hence, if the pillar were perfectly perpendicular, the axis, on a supposition that the measures were accurately taken, would be perfectly horizontal. But we know that a plumb-line is perpendicular whenever it is at rest, therefore any contrivance that will measure very minutely the distance from the plumb-line to the plane of the circle, both above and below, will determine whether or not the axis is horizontal; this contrivance is what we have to describe:

Conceive the said bar of measurement to terminate at one end after the manner of a two-pronged fork, and suppose one-half of a compound microscope, viz. the object, object-lens, and body of the instrument, to be carried by one prong of the fork, and the eye-glass in a separate tube, borne by the other prong; and it is easy to apprehend, that the image of any small object, whatever it may be, may by the adjustment of the object-lens be made to fall into the open space between the prongs, which image may again be rendered distinct to the eye by the focal adjustment of the eye-glass; we have now got a measuring-bar with a compound microscope carried by it, in two separate halves, so that any substance that will pass between the prongs of its forked end may be brought into the field of view, and be seen magnified by the eye-glass, used on the principle of a simple microscope: let the thread of the plumb-line be this interposed body, which indeed will cover only a small portion of the field of view; but as the plumb-line is not to be moved, except by the screw at the point of suspension, nor even touched by any external object, the microscope must necessarily be brought to it, and placed in such a manner that the thread will bisect the field of view; this is done by fitting the forked end of the measuring-bar into the upper frame E, first, in such a way that it may be made to slide in and out any number of times to the same situation; then the adjustments of the frame, or of the cock of suspension, will bring the thread into the field of view; let now the object be a round dot on a slip of ivory, or mother-of-pearl would be better, perhaps, and its image may be so adjusted that the plumb-line will bisect it in its magnified state. This ingenious contrivance of producing an image in the open air has been denominated Ramsden's ghost by succeeding instrument makers, from the name of its inventor. Let now the measuring-bar, which we will suppose to be too short, be laid and supported horizontally in a direction just perpendicular to the plane of the circle, and let there be a thick pin screwed into its end next the circle, which by being unscrewed will approach the plane of the circle till it just touches it as the circle revolves, then the distance from the extreme end of this pin to the plumb-line is exactly gauged; it is of no importance what may be the total length of this gauge, provided it be kept unaltered; remove, in the next place, the measuring-rod and its apparatus at each end in statu quo, to a similar fitting made for it in the inferior frame I F; and if, when the plumb-line bisects the image of the dot here as it did before, which the adjustments of the frame only must now effect, the pin at the opposite end turns out to touch the plane of the circle below at the same right angle that it did above, then the plane is perpendicular, and the axis necessarily horizontal; but if there is any deviation, the adjusting-screw, p, on the bearing frame, D D, must rectify one-half of this deviation, and the pin which screws into the measuring-bar the other half; after a few trials above and below, the horizontal position may be given to the axis in question to the exactitude of a single second; for we have said, that a microscope may be depended on to that degree of accuracy in reading off the micrometer's scale. When the vertical circle is truly fixed, a second measuring-bar may be added at the lower frame, while the first remains at the upper one, and the turning the circle round on its axis would show both above and below when any alteration takes place in the true position, from whatever cause. But instead of using the plane of the circle itself, Ramsden judged it better to fix a little bridge, $x\,y$, over the object-glass of the telescope, with a prominence, h, which he made to come in contact with the pins of the measuring-rod above and below successively, by which means the contact is more nicely observed, and the method equally accurate. Whenever the line of collimation of the telescope is thus adjusted, it will be certain to describe a semi-circle in the heavens, when turned half round, which will be truly perpendicular to the horizon, whether that semi-circle be in the meridian or in

any given azimuth. Whenever Piazzi rectified the superior and inferior micrometers and plumb-line, he took care to use the zeros of the vertical circle as the points that bisected the circle best into two equal semi-circles; and he gave as a reason, that he found these did not deviate more than a quarter of a second from their true places. When the vertical circle is used in taking altitudes, it may be clamped by a piece, *k*, on the pillar P, which when loose will allow a quick motion, but when fast will only permit a very slow one by means of the handle, V, of the compound-joint, which like that at Q is connected with the tangent-screw out of sight. These, we believe, are all the essential parts of this highly-important instrument.

The theory of the telescope would not be understood by the reader without a preparatory acquaintance with the science of optics, and we purpose under the article TELESCOPE giving a very full account of that form of the instrument which is best fitted for astronomical purposes; but there is a very important part of the furniture of the observatory which must be noticed here, we mean the frame-work and supports for the telescope. One of these, contrived by Sir William Herschel, is represented in the centre of the observatory (Plate, ASTRONOMY, *fig.* 2), in which A is the elevated mouth of a seven-feet tube, and B the place of the large speculum that reflects the rays of light back to the small diagonal plane metal near C, which, by a second reflection, brings them to a focus at the eye-piece below C, as seen in the engraving. Above C is the finder, the upper end of which has a small achromatic object-glass, and the lower end the eye-glass. The upper end of the tube rests on a support, D, which is capable of being raised or depressed by a pinion on the axis of the handle under D, while the lower end rests on the horizontal bar of the frame E F, which is suspended by a pulley over F; the four pivots *a*, *b*, *c*, and *d*, of the said frame, sliding in the open grooves, seen near those letters in the main frame, keep the small frame in any given situation, and allow a free motion, first down the vertical, and then down the inclined pieces that compose the main frame, as low as to G and H; and when the lower end of the tube has been depressed into this situation, the tube may have an elevation approaching towards the zenith: for not only is the upper end elevated by the handles at J for the quick, and at D for the slow motions; but the lower one is depressed by the handle at I, round which the cord is coiled, that goes round a fixed roller at K, and two others at L and M, before it embraces the pulley N, and is hooked to a pin at O above the frame. The rest of the main frame is so clearly exhibited in the engraving, that no farther description of it is necessary. In some of the instruments of this construction, when the handle J is omitted, and a quicker motion in altitude is required, and also a greater elevation than can be given simply by the handle at D, the second square stem that carries the pinion of the handle, is raised by hand, and kept to its elevation by means of a second rack, when this squared stem is lowered again. The quick motion in azimuth is given by sliding the lower end of the tube gently along the bar on which it rests, or by moving the whole frame, which moves on castors; but the slow motion is produced by a screw. It is scarcely necessary to add that the eye of the observer is applied to the side of the tube near its mouth, when the finder has pointed the tube properly to its object.

Most observatories possess an instrument called an armillary sphere. In the present day, it is more used for elucidating the general principles of astronomy, than for practical research; it may, however, be advisable to give a description and graphic delineation of the instrument.



It consists, as is seen in the figure, of an artificial sphere, composed of a number of circles of metal, put together so as to represent the ecliptic zodiac, tropics, and other imaginary circles in the heavens, in their natural order.

The earth is situated in the centre of this sphere, in the same plane with the rational horizon, which horizon, *d*, is generally represented by a broad silvered circle, divided into degrees, &c. The whole machinery is usually supported upon a brass stand, and is moveable about an axis, within a brass meridian like the common globes.

This meridian is likewise moveable within the silvered horizon, so as to admit the elevation or depression of the poles, *f*. The use of this sphere is to assist the imagination in conceiving the apparent motion of the celestial bodies. The student must suppose himself to be placed upon the earth, with the various circles in the heavens revolving round him from east to west.

Having in the preceding pages entered pretty fully into the construction of the instruments employed in practical astronomy, it may now be necessary to furnish a notion of the sort of edifice best fitted for containing them. A very useful observatory is represented in Plate, ASTRONOMY, *fig.* 2. It consists of a circular building with a moveable roof of similar form. The latter is made to revolve on friction rollers, and a contrivance of a winch and pulley enables the observer to elevate or depress the moveable ceiling in the lantern at pleasure. Various instruments are seen round the room, and amongst the rest an armillary sphere, to which allusion has already been made. Shutters for presenting the tube of the telescope in various aspects are also employed, towards one of which the large instrument is directed.

We do not purpose in the present place entering into the history of observatories, as that branch of the subject will be discussed under the article itself; but it may be advisable to give a description of a very excellent modern establishment in the sister

kingdom, erected without reference to expense for the express purpose of practical astronomy.

The observatory belonging to Trinity College, Dublin, commonly called the Dublin Observatory, was begun in the year 1783. It was founded by Dr. Francis Andrews, provost of that college, who bequeathed a large income for this purpose, which was to commence upon a particular contingency happening in his family. When this event had taken place, the College, with their wonted zeal for the promotion of science, determined not to lose time by waiting for the accumulation; but advanced from their own funds a sum considerably exceeding the amount of the original bequest.

They chose for their professor of astronomy and observer, the Rev. Dr. Usher, a man of extensive learning and indefatigable research, who was directed to proceed to England, to order from Mr. Ramsden the best instruments he could make, without any limitation of expense.

The apparatus first ordered was a transit instrument of six-feet focal length, with a four-feet axis, bearing four inches and a quarter aperture, with three different magnifying powers up to 600. An entire circle of ten-feet diameter, on a horizontal axis for measuring meridian altitudes; an equatorial instrument, with circles of five feet in diameter: an achromotic telescope, mounted on a polar axis, and carried by an heliostatic movement. Regulators were also ordered from Mr. Arnold, without any limitation of price. The situation chosen for the observatory is on elevated ground, about four miles from Dublin. The foundation is a solid rock of limestone, of several miles extent; and the soil is very favourable, being a calcareous substance, called limestone gravel, which is remarkable, absorbs rain, and thus contributes to dry the atmosphere.

The plan of the building unites at once both elegance and convenience: it fronts the east, and the lower range of windows and doors are twenty-three in number. In the centre there is a magnificent dome of three stories high, with a moveable roof for the equatorial instrument, which is placed upon a pillar of sixteen feet square, of the most substantial masonry, and surrounded by a circular wall of a foot distance, that supports the moveable dome, and also the floors, which in no part touch the pillar; thus, no motion of the floor or wall can be communicated to the instrument. The aperture for observation in the dome is two feet and a half wide.

But the most important erection belonging to this establishment is behind the main building, and at right angles to it, in order to obtain an uninterrupted view both north and south. This is the meridian or transit room, which contains both the transit instrument and the circle. It is thirty-seven feet long, twenty broad, and twenty-one high. Fine pillars of Portland stone are erected for both instruments, and the floor is so framed as to let all the pillars rise totally detached from it: and such was Dr. Usher's attention to extreme accuracy, that he first ascertained the pillars to be perfectly homogeneous, lest any variety in their substance might admit of a difference in their expansion or contraction by heat, cold, or other changes of atmosphere.

We cannot conclude this view of practical astronomy without quoting a remark made by a very enlightened critic in the *Quarterly Review*, who says, "when we look at the state of science on the Continent, pursued by academicians freed from the embarrassments of professional labour, and when we look at their numerous and well-appointed observatories, we shrink from the comparison which is thus forced upon our attention. We feel as if it were a species of treason to record the fact, that within the wide range of the British islands there is only one observatory, and scarcely one supported by the government! We say scarcely one, because we believe that some of the instruments in the observatory at Greenwich were purchased out of the private funds of the Royal Society of London. The observatories of Oxford, Cambridge, Dublin, Edinburgh, Armagh, and Glasgow, are all private establishments, to the support of which government contributes nothing." The consequence of this is, that many of them are in a state of comparative inactivity, and of but little service to the scientific world.

Works of reference on astronomy have not multiplied to the same extent as the printed treatises on many other sciences. The labour of a long life is necessary to the formation of a good book; and till the formation of Mr. Babbage's modes of calculation, a series of tables would alone occupy years of mathematical labour.

Of the numerous works on astronomy, we shall only mention here the latest and most important manuals and elementary works: *Astronomie par de Lalande*, 3rd edit., Paris, 1792, 3 vols., 4to. (there is an abridgment of it—*Abrége d'Astronomie par de Lalande*, Paris, 1795); *Astronomie Theorique et Pratique, par Delambre*, Paris, 1814, 3 vols., 4to.—a work important for professional astronomers; *Schubert's Theoretical Astronomy*, Petersburgh, 1798, 3 vols., 4to., and the new French edition of the same work, 1822; *Biot's Traité Elémentaire d'Astronomie Physique*, 2nd edit, Paris., 1810, 3 vols.; *Laplace's Exposition du Système du Monde*, 5th edit., Paris, 1824 (a general exposition of the results developed in the large work, *Mécanique Céleste*); *Bode's Illustrations of Astronomy* (which is confined to the less difficult propositions of geometry and astronomy), 3rd edit., Berlin, 1808, 2 vols.: together with this work, we may mention *Burjas' Manual of Astronomy*, Berlin, 1794, 5 vols., which requires, however, more extensive knowledge. Excellent, though very condensed, is *Bohnenberger's Astronomy*, Tübingen, 1811. *Piazzi's* Italian *Manual of Astronomy* is a good work. Among the English treatises are *Woodhouse's Elementary Treatise on Astronomy*, 1823, and *Ferguson's Lectures on Astronomy*, a popular work; also *Vince's Complete System of Astronomy*, 3 vols., 4to., with additions, 1814. To astronomers, practical and theoretical, *Bessel's Observations at the Observatory of Königsberg*, which have appeared in folio since 1813, are indispensable. Notices of astronomical tables may be found in the larger astronomical treatises mentioned. With respect to astronomical periodicals, *Zach's Monatl. Correspondenz zur Beförderung der Erd- und Himmels- Kunde*, with which is connected *Lindenau's and Bohnenberger's Astronom. Zeitschr.*, is continued under the title *Correspondence Astronomique, Géographique*, &c. *du baron de Zach*. Schumacher has also published, in Copenhagen, since 1822, *Astronomische Nachrichten*. The latest observations may be also found in the Paris *Connaissance des Tems*, and in the Berlin *Astronomisches Jahrbuch*, which has been published for more than fifty years. The history of astronomy may be found at large in Montucla's

Histoire des Mathématiques, 4 vols., 4to.; in Delambre's *Histoire de l'Astronomie Ancienne, celle du Moyen Age et Moderne*, Paris, 1817, 5 vols., 4to.; and in *Bailly's Histoire de l'Astronomie*, of which the first volume appeared in 1771, containing the history of ancient astronomy, and the three other volumes, 1779 and 1782, containing the history of modern astronomy, followed, in 1787, by his *Traité de l'Astronomie Indienne*, which latter work, however, must be used with precaution, on account of the inclination of the author to adopt theories on insufficient grounds, which indeed is one of the faults of his school.

Mrs. Somerville's excellent and learned treatise on the *Mechanism of the Heavens*, lately published, deserves the highest praise, both for general research and high mathematical attainments. This work will alone give a character to the literature of the age in which we live, and tend to place our fair country-woman foremost in the ranks of astronomical science.

Astroscope, an astronomical instrument, composed of two cones, on whose surface the constellations are delineated, by means of which the situation of the stars may easily be known.

Astroscopia; the art of examining the stars by telescopes, or, in plainer terms, practical astronomy.

Astrothemata, in *Astrology*, the positions of the stars in a plan of the heavens.

Astrothesia; the same as Astrum, which see.

Astrum; a constellation or assemblage of stars.

Astrum, in *Alchemy*, a term employed to denote the power imparted by chemical mixture.

Asymptote; commonly, a straight line, which approaches a curve line, so that the distance between them is constantly diminishing, although they can never meet, even if indefinitely continued. Hence Leibnitz called infinite spirits the *asymptotes of the Deity*. An asymptote may also be a curve.

Atabal; a kind of tabor used among the Moors, which is probably a word of Moorish extraction.

Atabulus; a provincial wind much felt in Apulia, of a dry and noxious quality. The ancient naturalists speak of the atabulus in terms of horror, on account of the ravages it made among the fruits.

Ataxy signifies irregularity of crisis, and paroxysms of fevers.

Ataraxia; exemption from disease or vexation. "The sceptics," says Glanville, "affected an indifferent equiponderous neutrality, as the only means to their ataraxia and freedom from passionate disturbances." So much for the clearness and simplicity of a much-praised author.

Atche, in *Commerce*; the smallest silver coin current in Turkey, worth about one-third of a penny sterling.

Atchievement, in *Heraldry*, denotes the arms of a person or family, together with all the exterior ornaments of the shield, as helmet, mantle, crest, scrolls, and motto, together with such quarterings as may have been acquired by alliances, all marshalled in order. *Hatchment*, as a funeral memento, is a vulgarism of the above.

Atebras, in *Chemistry*; a subliming vessel.

Ategar; a weapon among the Saxons, which seems to have been used as a hand dart.

A Tempo, in *music*; of similar signification with *a battuta*, and, like that expression, seldom used but when the time has been interrupted. *A tempo*, in any kind of fencing or fighting, means a blow or thrust at the same time with the antagonist's blow or thrust. It is, of course necessary that *a tempo* blows should be made in such a way as to afford at the same time a guard against the other's thrust, or to prevent its full effect. This kind of blow takes place particularly in fighting with the broad-sword, when the antagonist leaves himself much exposed.

Atempo Giusto, in *Music*, signifies, to sing or play in proper time.

Athanasia, in ancient *Medicine*; an epithet given to a kind of antidotes, supposed to have the power of prolonging life, even to immortality. In the *Augustan Dispensatory* we still find a medicine under the appellation of "athanasia magna," recommended against dysenteries and hæmorrhages.

Athanati; a peculiar body of cavalry, among the ancient Persians, consisting of 10,000 men, always complete, because, when any one of them died another was immediately put into his place.

Athanor, in *Chemistry*; a digesting furnace, which retained the heat for a long period of time, and was so contrived that it might be increased or diminished at pleasure.

Athena, in *Medicine*; a plaster or liniment recommended against wounds of the head and nerves, of which we find descriptions given by Oribasius, Ælius, and Æginata.

Athenatorium, in *Chemistry*; a thick glass cover, to be luted to a cucurbit when the alembic is taken off.

Athenorius Catapotium, in *Medicine*; a cough pill mentioned by Celsus, consisting of myrrh, pepper, castor, and opium.

Athenippum, in *Medicine*; an affusion for the eyes.

Atheroma, in *Surgery*, is a soft, pultaceous, uninflamed tumor; generally contained within a cyst, or bag. The cure of this swelling consists in its removal with a scalpel. It is very common on the finger joints.

Athwart, when used in navigation, implies across the line of the course.

Athwart-Hawse; the situation of a ship when she is driven by the wind, tide, or other accident, across the fore-part of another. This phrase is equally applied when the ships bear against each other, or when they are at a small distance: the transverse position of the former to the latter being principally understood. *Athwart the fore-foot* denotes the flight of a cannon-ball from one ship across the course of another, to intercept the latter, and oblige her to shorten sail, that the former may come near enough to examine her.

Atlantides, in *Astronomy*; another name for the Pleiades.

Atlantides, in *Architecture*; pillars used like the Caryatides, to support an edifice.

Atlas, in *Anatomy*; the first vertebræ of the neck, which supports the head.

Atlas, in *Commerce*; a very beautiful species of Chinese manufacture, now but little used. It consisted of a mixture of metal and silk, and was bought with avidity at very high prices.

Atmosphere. This is the ordinary title of the elastic fluid in which we live and breathe. The weight and pressure of the atmosphere has already been examined under the article Air, and will be further discussed when treating of the Barometer; but there are some interesting facts connected with the atmosphere which may properly have a place here.

The atmosphere may be considered a universal solvent, and though itself *inodorous*, it is the medium of all smells, and dissolving the different odorous effluvia, is charged with the emanations of all the various substances it sweeps.

When we reflect upon this ever-agitated heterogeneous fluid, compounded of the most active elements of life and destruction, constantly combining,—separating, now evident to the most ordinary sense, now escaping the grasp of imagination, we cannot, rationally, be surprised at the little, comparatively, that is really known concerning it. All within the power of the most ardent student is to collect the few facts that are established, to dismiss conjecture and hypothesis, and to apply himself to make additions to our knowledge by carefully observing, and accurately and luminously describing, the processes during which he is permitted to be present.

"By invisible, but ever-active agencies, the waters of the deep are raised into the air, whence their distribution follows, as it were by measure and weight, in proportion to the beneficial effects which they are calculated to produce. By gradual, but almost insensible, expansions the equipoised currents of the atmosphere are disturbed, the stormy winds arise, and the waves of the sea are lifted up; and that stagnation of air and water is prevented which would be fatal to animal existence. But the force which operates is calculated and proportioned; the very agent which causes the disturbance bears with it its own check, and the storm, as it vents its force, is itself setting the bounds of its own fury."—*Daniel's Essays.*

It is evident, from a slight view of these "complicated and beautiful contrivances," that it is hopeless to expect that all the causes of the phenomena of the atmosphere will ever be entirely attained by human science. At present but few are known, and those imperfectly. Amongst the principal ones which most affect the subject of our present inquiry are, undoubtedly, heat and electricity. The first raises and suspends the evaporated waters invisibly in the air, until some more powerful attraction dissolves the union, and the deserted moisture, exposed to view, falls again to the earth, and revisits it in the various forms of clouds, mist, rain, dew, snow, hail, sleet, and hoar-frost. To electricity may be principally attributed the more splendid phenomena of lightning, the aurora-borealis, and the other igneous meteors. And the effect of these causes, variously combined and infinitely modified by other agents, is felt in those currents of atmospheric air, which are described by a sacred writer, as "going toward the north, and toward the south, as whirling about continually and returning again according to their circuits."

Professor Leslie furnishes the following plain and simple facts on the subject.

"The mean height of the barometer (that is, the mean weight or pressure of the atmosphere) at the level of the sea, is the same in every part of the globe.

"The barometer constantly descends in a geometrical progression for equal ascents in the atmosphere, subject to a correction for the decreasing temperature of the elevation.

"The mean temperature of the earth's surface increases gradually from the poles to the equator.

"The mean temperature of the atmosphere decreases from below upwards in a regular gradation.

"The barometer at the level of the sea is but slightly affected by the annual or diurnal fluctuations of temperature; but, in the higher regions of the atmosphere, is, on the contrary, greatly affected by them.

"The heating and cooling of the atmosphere, by the changes of day and night, take place equally throughout its mass.

"The average quantity of vapour in the atmosphere decreases from below upwards, and from the equator to the poles.

"The western coasts of the extra-tropical climates have a much higher mean temperature than the eastern coasts.

"A wind generally sets from the sea to the land during the day, and from the land to the sea during the night, especially in hot climates.

"Between the tropics the fluctuations of the barometer do not much exceed one quarter of an inch, while, beyond this space, they reach to three inches.

"In the temperate climates the rains and the winds are variable.

"As we advance towards the polar regions, we find the irregularities of the wind increased; and storms and calms repeatedly alternate, without warning or progression.

"In the extra-tropical climates, a fall in the barometer almost always precedes a period of rain, and indicates a change or acceleration of the aerial currents.

"Barometers, situated at great distances from each other, often rise and fall together with great regularity.

"More than two currents may often be traced in the atmosphere at one time, by the motions of clouds, &c.

"The force of the winds does not always decrease as the elevation increases; but, on the contrary, is often found to augment rapidly.

"The variations of the barometer are less in high situations than in those at the level of the sea.

"In Great Britain, upon an average of ten years, westerly winds exceed the easterly in the proportion of 225 to 140; and the northerly winds exceed the southerly, as 192 to 173.

"Northerly winds almost invariably raise the barometer, while southerly winds as constantly depress it.

"The most permanent rains from this climate come from the southern regions.

"The mean height of the barometer varies but little with the changes of the seasons.

"The apparent permanency and stationary aspect of a cloud is often an optical deception, arising from the solution of moisture on one side, and its precipitation on the other.

"The quantity of vapour in the atmosphere in the different seasons of the year (measured on the surface of the earth, and near the level of the sea) follows the progress of the mean temperature.

"The pressure of the aqueous atmosphere, separated from that of the aerial, generally exhibits directly opposite changes to the latter.

"Great falls of the barometer are generally accompanied by a temperature above the mean for the season, and great rises by one below the same."

The same authority also states, that "the British islands are situated in such a manner as to be subject to all the circumstances which can possibly be supposed to render a climate irregular and variable. Placed nearly in the centre of the temperate zone, where the range of temperature is very great, their atmosphere is subject, on the one side, to the impressions of the largest continent of the world; and, on

the other, to those of the vast Atlantic Ocean. Upon their coasts the great stream of aqueous vapour, perpetually arising from the western waters, first receives the influence of the land, whence emanate those condensations and expansions which deflect and reverse the grand system of equipoised currents. They are, also, within the frigorific effects of the immense barriers and fields of ice, which, when the shifting position of the sun advances the tropical climate towards the northern pole counteract its energy, and present a condensing surface of enormous extent to the increasing elasticity of the aqueous atmosphere.

Heat is one of the most important agents resorted to in the economy of creation for revivifying the atmosphere. This is effected by the constant operation of aerial currents familiarly termed *winds*. By this means the whole of the ingredients of the atmosphere are continually amalgamated together; for we find that though the atmosphere may diminish in lightness as we ascend, there is precisely the same general character pervading its particles. Without winds the air would become putrescent and stagnant by the thousand effluvias of a crowded city, and our own, "giant metropolis," would be little better than one vast lazar house. It should, however, be borne in mind, that the smoke of our coal fires is not as injurious to health as is generally imagined, and the prejudice which originated in Evelyn's "Fumifugium," is now giving way to a more accurate chemical acquaintance with the antiseptic properties of common carbon. To explain the theory of the winds, we cannot do better than select one particular species of aerial current, which may serve to illustrate the phenomena generally.

The *trade-winds*, which, within the tropics at all times constantly blow from the east, but somewhat vary their force, and decline a little to the north or the south, according to the latitude and the season, are the most remarkable of all the aerial currents, and of signal importance in navigation. These steady breezes favoured the voyages of Columbus, and conducted him to the discovery of the Mexican archipelago. The same powerful stream afterwards drew the Portuguese from their southern course, and carried them to the shores of the Brazils. Since the character and extent of those winds have become perfectly known, the navigator reckons safely on their aid, and shapes his voyage in such a way as to reduce its performance almost to a calculation.

The cause of the trade-winds, however, is not obvious, or very easily traced. Various attempts have been made to explain their principle of action, yet seldom on any solid or accurate principles. It would form an interesting discussion to examine the different hypotheses advanced; but we can afford room to notice very briefly the most considerable only of these opinions.

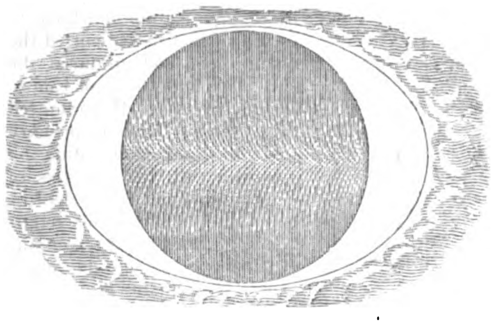
Des Cartes, and his followers, imputed the trade-winds to the inertia of the atmosphere, which they conceived prevented the air acquiring the full rotation of the earth, especially near the equator. The wind being thus left behind, as the globe rolled from the west, would have an apparent motion in the contrary direction, and seem to blow from the east. But it may be urged, that as passengers almost insensibly gain the celerity of the ship which carries them, so every portion of the incumbent atmosphere, though more loosely attached to the terraqueous surface, must soon acquire the peculiar motion corresponding to the parallel of latitude. Nor would the inequality of such combined movements in the air at all disturb the order and arrangement of its general mass.

Dr. Halley gave a different explication of the origin of trade-winds, which seems very plausible, and was for some time deemed quite satisfactory. This able philosopher and experienced navigator supposed that the spot where the sun's vertical rays exert their utmost heating energy, being in the lapse of a day successively transferred from east to west round the circumference of the globe, must, as a centre of confluence, draw in its train a current of air. The current thus formed would result from the excess of the air streaming from the east above that from the west; and it would therefore advance with a tardy pace, following at a distance the powerful energy of the sun. The same easterly wind might incline towards the north or the south, according as the great luminary appears to approach the northern or the southern tropic.

But it should be observed, that the torrid zone stretches mostly over the ocean, and includes only a narrow portion of land. The heat excited in succession through that liquid tract, by the diurnal passage of the sun, is hence extremely small, and hardly sufficient to produce the gentlest air. Nor could even this feeble current have a decided and constant direction: it would only tend towards the heated part of the surface of the ocean. In the morning, it would breathe from the west; about noon, it would become neutral, and die away; and in the evening, it would again spring up and flow from the east. Near midnight this current would sink into a perfect calm. The hypothesis will, therefore, not bear any strict examination. It is neither adequate to the production of such effects, nor accordant with the actual phenomena of the trade-winds.

The first who succeeded in taking a correct view of the question was George Hadley, in a short paper inserted in the *Philosophical Transactions* for 1735. By combining in some measure the idea of Des Cartes with the opinion of Halley, he produced a clear and simple account of the cause of trade-winds, which appears entirely consistent and free from every objection. Though the daily variation of temperature be very inconsiderable within the tropics, yet the annual accumulation of heat renders the equatorial regions much warmer than the higher latitudes, and consequently maintains a perpetual current of air from either side. If those aerial motions were not modified by the figure and rotation of the globe, there would always be two opposite winds blowing directly from the north and from the south to the equator. But the stream which perhaps originates at the northern tropic, in advancing to the equator, must seem gradually to deflect towards the west, in consequence of the increasing velocity with which the successive parallels of latitude are carried eastwards. During the time this current takes to perform its journey, it is apparently transported to the west, through a space equal to the excess of the arc traced by the tropic. The current from the southern tropic is equally bent towards the west. When both of them meet at the equator their opposite impulsions from the north and south are extinguished, and they flow directly west in a single united stream, and with accumulated force. The apparent motions of the different streamlets, which from both hemispheres

conspire to constitute the trade-wind, is represented in the accompanying diagram.



But it is not enough to connect the general facts; a complete theory should harmonize all the subordinate details. An easy calculation accordingly conducted to those precise results which are commensurate and exactly congruous with the actual phenomena. The trade-wind may be reckoned to begin about the latitude of 25 degrees. At this parallel, the mean temperature is four centesimal degrees colder than immediately under the equator, which difference of heat may graduate through the atmosphere to the altitude of 10,000 feet. Wherefore, the expansion of the air at the equator, which draws to it a meridianal wind, will amount to a column of 100 feet. The velocity of the current hence produced, must be about 80 feet every second, which corresponds to 54 miles in the hour. But each point on the parallel of 24°, is carried eastward by its revolution about the earth's axis, 7 miles faster every hour than on the parallel of 25°. Consequently, when the wind arrives at the parallel of 24°, it will seem to have acquired a tendency of 7 miles an hour to the west. As it reaches the successive parallels of 23°, 22°, 21°, &c. it will gain continual, though decreasing additions to its apparent westerly course, which at the equator will have augmented to 104 miles in the hour.

In this calculation, we have made no deduction for the resistance which the streams of air must experience in sweeping over the surface of the globe, because no experiments have been made to ascertain the effect of such retardation. It is no doubt less on the ocean than on the land, and must evidently be diminished in proportion to the depth of the mass of fluid which is borne along. Still, however, this obstruction, joined to this impediment of internal motion, must be very considerable; and we may safely reduce the numbers before stated to one-third, which would give 18 miles an hour for the celerity of the primary meridianal wind, and 35 miles for that of the oriental or trade-wind, resulting from the influence of the figure and rotation of the earth.

From the laws of universal attraction it has been inferred, that these celestial bodies must act upon the atmosphere, or that they must occasion a flux and reflux of the atmosphere, as well as that of the ocean. Hence it has been alleged, that though we cannot discover aerial tides, of ebb or flow, by means of the barometer, because columns of air of unequal height, but different density, may have the same pressure or weight; yet the protuberance in the atmosphere, which is continually following the moon, must, they say, of course produce a motion in all parts, and so produce a wind more or less in every place, which, conspiring with, or counteracted by the winds arising from other causes, makes them greater or less. Several dissertations to this effect were published, on occasion of the subject proposed by the Academy of Sciences at Berlin, for the year 1746. Although the atmospherical air is much more variable than water, and the action of the sun and moon upon it becomes much less apparent to us, because they must frequently concur with, or be counteracted by the much more powerful effects of heat and cold, of dryness and moisture, of winds, &c., so that their action upon the barometer has been long disputed and even denied; yet that the moon in particular, as well as the sun, has such an action, has been for a considerable time surmised; and of late years it has been in a degree observed and rendered sensible by means of very accurate and long-continued barometrical observations, and perceived merely by taking a mean of the observations of many years. Toaldo, the learned astronomer of Padua, after a variety of observations made in the course of several years, found reason to assert, that, at the time of the moon's apogeum, the mercury in the barometer rises the 0.022 of an inch higher than at the perigeum; that at the time of the quadratures, the mercury stands 0.008 of an inch higher than at the time of the syzygies; and that it stands 0.022 of an inch higher when the moon in each lunation comes nearest to our zenith, (meaning the zenith of Padua, where the observations were made), than when it goes farthest from it.

In the seventh volume of the *Philosophical Magazine*, there is a paper of L. Howard, Esq. which contains several curious observations relative to this subject. This gentleman found, both from his own observatians, and from an examination of the Meteorological Journal of the Royal Society, which is published annually in the *Philosophical Transactions*, that the moon had a manifest action upon the barometer. "It appears," he says, "to me, evident, that the atmosphere is subject to a periodical change of gravity, by which the barometer, on a mean of ten years, is depressed at least one-tenth of an inch, while the moon is passing from the quarters to the full and new; and elevated, in the same proportion, during the return to the quarter." A great fall of the barometer generally takes place before high tides, especially at the time of new or full moon.

The causes, it is said, which render the diurnal tide of the atmosphere insensible to us, may be the elasticity of the air, and the interference of the much more powerful effects of heat, cold, vapours, &c,

It has been calculated by D'Alembert, from the general theory of gravitation, that the influence of the sun and moon in their daily motions is sufficient to produce a continual east wind about the equator. So that, upon the whole, we may reckon three principal daily tides, viz. two arising from the attractions of the sun and moon, and the third from the heat of the sun alone; all which sometimes combine together, and form a tide of great magnitude.

In corroboration of the opinion of the influence of the sun, and principally of the moon, in the production of the wind, we must likewise mention the observations of Bacon, Gassendi, Dampier, Halley, &c.; namely, that the periods of the year most likely to have high wind are the two equinoxes; that storms are more frequent at the time of new and full moon, especially those new and full moons which

happen about the equinoxes; that, at periods otherwise calm, a small breeze will take place at the time of high water; and that a small movement in the atmosphere is generally perceived a short time after the noon and the midnight of each day.

ATMOSPHERIC CLOCK; a machine for measuring
ATMOSPHERIC STONES; see AEROLITHS.
the mean temperature of the air.

ATOLLENS OCULI, in *Anatomy*, one of the muscles of the eye, usually called the elevator oculi.

ATOMIC PHILOSOPHY. The nature of the ultimate elements of which bodies are constituted, has been a fruitful source of speculation among philosophers of all ages. From the earliest times of antiquity down to the present day, two opinions directly opposed to each other have divided the world on this subject; the one, that matter is composed of an assemblage of minute particles or *atoms* incapable of farther division,—the other, that there is no limit to its divisibility, the smallest conceivable portion still consisting of an infinity of parts. The first of these theories, which is commonly distinguished by the name of the Atomic philosophy, was originated in Greece by Leucippus; it was supported by Democritus, and subsequently considerably improved by Epicurus. It also existed at a very early period among the Hindoos, as Mr. Colebrooke* has shown, and formed the prominent feature of the doctrines of the Vaiseshica school of philosophy. According to Canade, the reputed founder of that sect, material substances are primarily atoms, and secondarily aggregates. These atoms are eternal, and the mote which is seen in a sun-beam, and which is the most minute of perceptible things, consists of several of them. They are simple and uncomposed; else the series would be endless, and were it pursued indefinitely, there would be no difference of magnitude between a mustard-seed and a mountain, a gnat and an elephant, each alike consisting of an infinity of particles. The ultimate atom then is simple. Two of these atoms concurring by an unseen peculiar virtue, the creative will of God, time, or other competent cause, constitute a binary or double atom, which is the first compound; by the concourse of three binary atoms, a ternary atom is produced, which is the second compound; the next is formed by the union of four ternary atoms, and is a quaternary atom, and so on to grosser masses or aggregates. In this manner Canade accounts for the formation of all material bodies, from these four of the nine substances or elements recognised by the Hindoo philosophers, the existence of which is deduced from distinct perception. Thus, great earth, as he terms it, is produced from earthly atoms, great water, from aqueous atoms, great light or heat, from luminous, and great air from aerial ones.

This doctrine bears a considerable analogy to that embraced by the earlier philosophers of Greece, who in many instances seem to have entertained views more conformable to the principles of modern science than their successors. Anaxagoras supposed the material world to consist of minute particles, but contended that those particles were of different kinds, the peculiar form and properties of any substance depending on the nature of the particles of which it was chiefly composed. He also maintained the existence of an active intelligent principle, or infinite mind, distinct from matter, and possessing a power of motion within itself, the communication of which, to the passive particles of the material mass, caused the union of the homogeneous ones, and produced the various forms of nature. The hypothesis of Empedocles was a simplification of this. He admitted the existence of only four different kinds of primary particles, and accounted for their aggregation by conceiving them to be endued with the qualities of friendship and discord; or, as in modern scientific language we should call them, affinity and repulsion. These qualities being excited by the communication of motion to the original material mass, through the agency of the active intelligent principle of nature or Divine mind, their operation he supposed to lead to the union of homogenous atoms, and the separation of heterogenous ones; and consequently to the formation of four elements, as he termed them, —air, earth, fire, and water, by the intermixture of which, in various proportions, he imagined all other substances to be produced. Both of these philosophers maintained the existence of several essentially distinct kinds of particles; they disagreed only as to the number of those classes, Democritus admitting but four, and Anaxagoras imagining a separate class for every different compound in nature. Leucippus attempted to reduce it still farther; he derived the whole material world from one elementary kind of matter, consisting of minute indivisible corpuscles or *atoms*, of various shapes, insensible, and possessed of an intrinsic power of motion. By the agency of this power, the intervention of a Divine mind in the formation of the various objects in nature, which had been recognised by preceding philosophers, was dispensed with, and their production accounted for by the fortuitous concurrence of atoms of similar forms. Independently of its atheistical tendency, a fatal objection to this doctrine is, that each particular atom being supposed insensible, no collection of atoms can become sensible. It was probably, as Bayle thinks, from a conviction of this difficulty that Democritus, the follower of Leucippus supposed every atom to be endued with a soul, although on other points he, agreed with his master. But Epicurus, who is considered the great supporter of the ancient atomic philosophy, rejected this innovation, and adhered in this respect to the original notion of Leucippus. He ascribed the formation of the various material bodies of the universe to the union sometimes attending the casual collision of two wandering atoms, which, from the jagged or pointed shape of one of them, might happen to adhere. The compound would probably possess interstices just adapted to corresponding projections of other atoms which would consequently on meeting, unite to it. When these primary atoms were closely connected, with but little space between, they produced solids, such as stones and metals; when loose and disjoined, the resulting compound was of lax texture, as wood, water, and vapour.

The arguments adduced by the advocates of the doctrine of the existence of ultimate atoms, were various. They contended that without, such an arrangement, there would be no durability in the system of nature; that the component particles of matter, gradually worn down by constant attrition, during a period of indefinite extent, would eventually become

* Essay on the Philosophy of the Hindoos, part II, in the *Transactions of the Royal Asiatic Society*, vol. I, page 104; and not in the *Asiatic Researches*, to which Dr. Daubeny by mistake refers, in his *Introduction to the Atomic Theory*.

unable to form any thing possessing bulk and solidity; or else would produce substances of a very different nature from those which they gave rise to formerly, when in a less comminuted state. And hence, added they, the races of animals and the tribes of plants could not have preserved their uniformity for so long a period, if the particles out of which they were formed had undergone any change in size and figure; for, from those two qualities arose, according to their doctrine, all the distinguishing marks which characterise a body. They also argued, that as every material body which comes under our observation does possess a definite size, so ought each of the parts of which it consists.

Among the moderns, the same diversity of opinion prevailed which divided the ancient world. By Leibnitz, the existence of atoms was denied, as inconsistent with two of his leading dogmas—the law of continuity, and the doctrine of a sufficient reason. The very notion of an atom, he contends, implies that of absolute hardness; now, if two bodies perfectly hard, and therefore altogether inelastic, were to meet with equal and opposite motions, they must both necessarily stop at once. Hence, to suppose the existence of bodies so constituted as to pass instantly from a state of rapid motion to one of perfect rest, is inconsistent with the law of continuity, which implies that no change can take place abruptly, or without passing through the intermediate gradations.

More intelligible are the arguments advanced by Des Cartes, and the host of philosophers who attached themselves to his theory during the seventeenth century; these contented themselves for the most part with proving, that no body can be considered in a mathematical sense incapable of division. No compound or visible bodies, it is well known, ever come into immediate contact with each other, or influence each other by means of simple solidity. The earth is affected by the sun, the moon by the earth; the waters of the earth by the moon. The particles of all bodies deemed the most solid and impermeable, are capable of approaching nearer, or receding farther from each other, by an application of different degrees of cold or heat. We can, hence, it is said, form no conception of perfect solidity; and every phenomenon in nature appears to disprove its existence. The minutest corpuscle we can operate upon, is still capable of a minuter division, and the parts into which it divides possessing the common nature of the corpuscle which has produced them, must necessarily, it is added, be capable of a still farther division; and as such divisions can have no assignable limit, matter must necessarily and essentially be divisible to infinity. This argument, indeed, is highly plausible; but it was soon obvious that it leads to a pure nonentity of a material world: for that which is essentially unsolid, and infinitely divisible, must at length terminate in nothing. And hence, Leibnitz, about half a century, and Boscovich, about a century afterwards, attempted to amend the system, by contending, as indeed Zeno is supposed to have done formerly, that matter has its ultimate atoms or monads, as they were denominated by Leibnitz, from the language of Pythagoras, beyond which it is altogether indivisible; and that these ultimate atoms or monads are simple unextended points, producing however the phenomena of extension by their combination, and essentially possessed of the powers of attraction and repulsion.

The object of Boscovich, in framing this hypothesis, was to get rid of the difficulty of imagining the property of extension to belong to a body taken collectively, when the same is not predicated of its component parts. For this purpose he still adhered to the supposition, that matter is made up of a number of unextended points, but attempted to account for the extension, which a combination of them possesses, by resolving the very idea of that property itself into something more simple,—the resistance offered by a combination of particles to the approach of another combination of similar particles, in consequence of those particles being endued with the power of repulsion at certain distances. This would certainly produce the effect which results from the property which we usually term impenetrability; and it is from that primary property of matter that the notions of substance, figure, and bulk, included under the term extension, arise. But the ingenuity of Boscovich, though enabling us to maintain in argument the doctrine of particles mathematically indivisible, can hardly persuade us of the reality of their existence, and we shall evade the objection which may on this account be alleged against the theory of indivisible atoms, yet still possessed of extension, by considering those atoms as bodies not destitute indeed of parts, but having those parts held together by a force capable of resisting any attempt by natural means to separate them. Upon this supposition we may fairly speak of, or reason on, the ultimate particles to which the division of matter can be carried, even though they may be proved mathematically to consist of an infinite number of points. This theory, though opposed by Kant, and the more modern German schools of philosophy, was the view taken by Newton. "All things considered," observed that philosopher, "it seems probable that God in the beginning formed matter in solid, massy, hard, impenetrable; moveable particles, of such sizes and figures, and with such other properties, and in such proportion to space as most conduced to the end for which he formed them."

But the strongest proofs which we posses of the correctness of the hypothesis, that matter consists of a finite number of indivisible particles, are derived from the discoveries of modern chemists, relative to the definite proportions in which substances combine; from the laws which have been observed to regulate the phenomena of crystallization, and from the researches of Professor Mitscherlich into the correspondence which frequently exists between the crystalline form of compound bodies, and the number of their constituent atoms; and which he has denominated *isomorphism*. Of the first we shall speak in the next article, the others we shall notice under their respective heads. In addition, we may observe, that this theory is strongly supported by one or two exceedingly ingenious arguments deduced entirely from recent observation and experiment. In a memoir on the Finite Extent of the Atmosphere, published in the *Philosophical Transactions* for the year 1822, Dr. Wollaston has observed, that upon the supposition of the contrary hypothesis, the matter composing our atmosphere ought to extend throughout space. For being a permanently elastic fluid, the force of repulsion which continually tends to keep its particles asunder, must operate wherever any portion of air exists; consequently, if it be infinitely divisible, there ought to be no limit to its extent. On this supposi-

tion all space would be filled with matter, and in that case, the different heavenly bodies would attract to themelves an aerial fluid of more or less density in proportion to their respective bulks. The occultation of Venus, by the body of the sun, or the passage of that planet behind it in May, 1821, afforded the means of ascertaining whether this were the case with respect to the sun; for from the well-known optical phenomena of refraction, the apparent position of a body seen through any one of these atmospheres, would differ from its real position in a degree proportionate to the density of that atmosphere. A series of observations was made, both on its approach to and departure from the sun, and in no one instance was the apparent position of the planet found to be in the least degree affected by any refraction of the rays proceeding from it through a solar atmosphere; thus, justifying the conclusion that none existed of that density, which would have surrounded it, had matter been uniformly diffused throughout space, or in other words, been infinitely divisible. On the other hand, if we suppose the atmosphere to be made up of atoms, or to consist of a finite number of elementary particles, incapable of farther division, the force of repulsion can only separate them up to that point; and that force being diminished in proportion to the increase of the rarity of the medium, in other words, of its elevation from the surface of the earth, it follows that at a certain height, the power of gravity which tends to draw the particles towards the earth, would counterbalance that of repulsion, which acts in a contrary direction, and thus render them stationary, and consequently at that distance would be found the limit of the atmosphere.

Dr. Faraday, in a paper on the Existence of a Limit to Vaporization, in the *Transactions* for 1826, has corroborated this view of the question, by showing that there is a certain temperature, and for most bodies not a very low one, at which all evaporation of their substance ceases, the force of gravity belonging to their component particles counterpoising that of the mutual repulsion which tends to destroy their cohesion. This, observes Dr. Daubeny, would not be the case if the matter of which those bodies consisted were infinitely divisible; for however low their temperature might be (always supposing it to be above the point of absolute privation of heat), in other words, however feeble the power of repulsion, yet, as it would be exerted on parts of matter which are by the very supposition so minute as to possess the counteracting force of gravity in a still weaker degree, it ought to continue to produce some effect.

From all the concurrent arguments we seem to be justified in concluding that a limit is to be assigned to the divisibility of matter, and consequently that we must suppose the existence of certain ultimate particles, stamped, as Newton conjectured, in the beginning of time by the hands of the Almighty with permanent characters, and retaining the exact size and figure, as well as the other more subtle qualities and relations which were given to them at the first moment of their creation. Whether, according to the doctrine of some philosophers, these particles all belong to one primary kind of matter, the πρωτη ὑλη of the Greeks, impressed with certain distinct properties, or with various modifications of the same property; or whether, as others imagine, several elementary kinds of matter were originally produced, the intermixture and union of which are the causes of the infinite variety of appearances that diversify the face of creation, is a question to which no decisive answer can be returned. The present state of our knowledge of nature would incline us to the latter opinion; while, the revolutions to which that knowledge is continually subject, forbids us positively to assert that the progress of discovery may not ultimately establish the truth of the former.

Atomic Theory; the expression which is used to designate the laws of the definite proportions in which chemical combination takes place between bodies.

It is a circumstance which could hardly fail to have attracted observation as soon as any progress had been made in chemical manipulation, that the same body, however produced, is at all times composed of the same ingredients in exactly the same proportions. Thus, if several portions of the substance known by the name of carbonate of potass, be analyzed, they will all be found to consist of certain quantities of carbonic acid and potass; and if the quantities of those elements, which enter into each be compared, the proportion of the weight of the acid to the weight of the alkali will invariably be that of 22 to 48, whether the portion of the compound examined be a pound, an ounce, or a grain. It would also have been observed, that the same body frequently united in more than one proportion with another; and that the different compounds thus produced by the union of the same substances in different proportions, often bore no relation whatever to each other, but seemed each to belong to a distinct class of bodies. One of them, for instance, might possess acid properties, the other be tasteless and inert; or one might be combustible, while the other supported or extinguished flame. It could not fail also to be remarked, that in those cases in which the chemical properties of the combining bodies were in a manner effaced by their union, they would not unite in every proportion; in other words, the number of combinations of which they were susceptible did not appear to be indefinite, that in fact there are few instances in which it exceeded four or five; and that when the ingredients were presented to each other in intermediate quantities, the resulting compounds were not in reality distinct, but mixtures of two or more of the combinations known to exist. This point being ascertained, it was natural that the relation which the several compounds, consisting of the same ingredients, might bear one to the other should be a subject of inquiry; and it is only surprising that men of science should so long have overlooked the simple law by which the combinations between bodies are now shown to be regulated.

The first step towards the determination of this point was made by a German chemist, of the name of Wenzel, who, in a work published at Dresden, in 1777, remarked, that when two neutral salts decomposed each other, the resulting compounds were exactly neutral. Thus, if sulphate of silver and nitrate of barytes were to be brought into contact, decomposition would ensue, and there would result two neutral salts—nitrate of silver and sulphate of barytes; and if to the nitrate of silver thus obtained, phosphate of soda were added, we should then have phosphate of silver and nitrate of soda, both also neutral. Hence the same quantity of sulphuric acid, that was combined with the silver in order to form sulphate of silver, is exactly sufficient to enter into combination

with the barytes, so as to form sulphate of barytes; and the same quantity of nitric acid, which was originally united with the barytes to form nitrate of barytes, exactly suffices to combine with the silver for the formation of nitrate of silver. Now 19.75 grains of dry sulphate of silver is made up of 5 grains of sulphuric acid, and 14.7 grains of oxide of silver; or, in other words, 5 grains of acid and 14.7 of oxide are requisite to form a neutral compound, or to neutralize each other's properties; and 16.5 grains of nitrate of barytes consists of 6.75 grains of nitric acid, and 9.75 of barytes. It is found, when these substances are presented to each other in these quantities, that the union of the sulphuric acid and the barytes produces a neutral compound, as does also that of the nitric acid and the silver; hence we conclude that 5 grains of sulphuric acid just suffice to neutralize 9.75 of barytes; and 6.75 grains of nitric acid to neutralize 14.75 of silver. These results are exhibited more conveniently in the following form.

Original Compounds.

5 grs. sulph. acid neutralize 14.75 grs. ox. sil.
6.75 nit. acid . . . 9.75. barytes

Resulting Compounds.

5 grs. sulph. acid neutralize 9.75. barytes
6.75 nit. acid . . 14.75. ox. sil.

Here we perceive that exactly 5 grains of sulphuric acid neutralize, or form a neutral compound with, both 14.75 grains of oxide of silver, and 9.75 of barytes; hence, 14.75 grains of oxide of silver are equivalent in their power of combining to 9.75 grains of barytes. We also observe, that just 6.75 grains of nitric acid are required to neutralize the same quantities of those bodies; it follows, therefore, that 6.75 grains of nitric acid are equivalent to 5 grains of sulphuric acid.

Now it is found that if the 21.5 grains of nitrate of silver (consisting of 6.75 grains of nitric acid, and 14.75 of oxide of silver) which result from the above process, be presented to 7.5 grains of dry phosphate of soda (containing 3.5 grains of phosphoric acid and 4 of soda) decomposition ensues, and the 4 grains of soda just suffice for the 6.75 grains of nitric acid, and the 14.75 grains of oxide of silver for the 3.5 of phosphoric acid; which we may express more conveniently thus.

Original Compounds.

6.75 grs. nit. acid neutralize 14.75 grs. ox. sil.
3.5 . phos. acid . . 4 soda

Resulting Compounds.

6.75 gr. nit. acid neutralize 4 grs. soda
3.5 . phos. acid . . 14.75 ox. sil.

Combining these results with those exhibited in the preceding table, we perceive at once that

$\left.\begin{array}{l}\text{6.75 grains nitric acid}\\ \text{5 . . . sulphuric}\\ \text{3.5 . . phosphoric}\end{array}\right\}$ are equivalent to each other in their power of combining;

and that

$\left.\begin{array}{l}\text{9.75 grains barytes}\\ \text{14.75 . . ox. silver}\\ \text{4 . . . soda}\end{array}\right\}$ are equivalent to each other in their power of combining.

Proceeding upon this principle, Richter, a Prussian chemist, endeavoured to ascertain the relative capacities of saturation belonging to the several acids and bases, and to express them by a scale of numbers. The results of his researches were published in the form of a table, but they were by no means so correct as those of Wenzel, whose accuracy indeed is remarkable. This table contains the equivalent quantities of some of the earths and alkalies which would be requisite to neutralize 1000 parts of sulphuric acid, and also the equivalent quantities of some other acid, which would be capable of producing the same effect as that quantity of the sulphuric. It might naturally have been expected that two inquiries would be suggested by this table of Richter's; the one with a view of ascertaining, first, whether the same law which had been established with respect to a few of the acids and bases held good generally throughout nature, and particularly where two or more combinations between one body and another existed; and secondly, whether, if such were the case, any relation could be traced between the different combining quantities of those substances which entered into combination in more than one proportion. But it was not until several years had elapsed that any attempt was made to determine either of these facts. It is, indeed, unquestionable, that so early as 1789, Mr. Higgins, in his *Comparative View of the Phlogistic and Anti-Phlogistic Theories*, published in that year, distinctly states, that one ultimate particle of sulphur, and one of oxygen constitute sulphurous acid, and one ultimate particle of sulphur and two ultimate particles of oxygen, sulphuric acid; and, moreover, that in the compounds of azote and oxygen, the ingredients are to each other in the respective proportions of 1 to 1, 2, 3, 4, and 5; but, it is evident, from the slight mention which he makes of this relation, that he was hardly aware of its importance.

In the year 1808, Mr. Dalton published the first volume of his *New System of Chemical Philosophy*, at the conclusion of which he announces as a general fact, that when two bodies combine, the union takes place betwixt their component particles in the proportion of 1 of the first to 1 of the second, 1 of the first to 2 of the second, 1 to 3, and so on. Hence, from the relative weight of the elements, constituting any given compound, that of their ultimate atoms may, with certain limitations, be inferred; and therefore, when either of the same ingredients occurs in a known proportion in other bodies, the number of its atoms present in them may admit of being determined. Two years afterwards, he published the second part of his System, in which he confirmed these views by a mass of facts derived from an accurate examination of the compounds of oxygen with other bodies; and, by the investigations of other chemists, they have been extended to all classes of chemical compounds whatever. It will at once be evident, that these doctrines of Mr. Dalton's comprehend two distinct, though mutually related propositions; whether it be true that the proportions in which bodies combine follow any numerical law, and secondly, whether, if such be the case, the circumstance may be accounted for, by supposing the union to take place between the atoms that constitute the substances in question, and that in each, the atoms are characterized by a difference of weight. The first point is a question of fact, which can only be established by observation, and which, so far as that observation has hitherto extended, is invariably found to occur. It would obviously exceed our limits to give any very detailed exemplification of its correctness; we shall therefore confine ourselves to the

following instances, which are derived from bodies whose composition has been sufficiently and accurately determined. To the different substances are prefixed the numbers, denoting the relative weights of the proportions in which they combine to form the compound marked; and the symbol + is used merely as a short and convenient substitute for the words *combined with*.

Oxygen and Hydrogen.

1 hydrogen + 8 oxygen, form water.
1 .. + 16 .. .. deutoxide of hydrog.

Oxygen and Carbon.

6 carbon + 8 oxygen, form oxide of carbon, (or carbonic oxide.)
6 .. + 16 .. .. carbonic acid.

Oxygen and Sulphur.

16 sulphur + 8 oxygen, form hypo. sulph. acid.
16 .. + 16 .. .. sulphurous acid.
16 .. + 24 .. .. sulphuric acid.

Oxygen and Nitrogen.

14 nitrogen + 8 oxygen, form protoxide of nitrog. (or nitrous oxide.)
14 .. + 16 .. .. deutoxide of nitrog. (or nitrous gas.)
14 .. + 24 .. .. hyponitrous acid.
14 .. + 32 .. .. nitrous acid.
14 .. + 40 .. .. nitrous acid.

Hydrogen and Sulphur.

1 hydrogen + 16 sulphur, form sulphuretted hydrog.
1 .. + 32 .. .. bisulphuretted hydr.

Hydrogen and Carbon.

2 hydrogen + 6 carbon, form sub-carburetted hydr.
2 .. + 12 .. .. carburetted hydrogen. (or olefiant gas.)

The same relation is also found to exist in combinations of compounds of simple bodies; thus:

Potass and Sulphuric Acid.

48 potass + 40 sulphuric acid, form sulphate of potass.
48 .. + 80 .. .. bisulphate of pot.

Potass with Oxalic Acid.

48 potass + 36 oxalic acid, form oxalate of potass.
48 .. + 72 .. .. binoxalate of potass.
48 .. + 144 .. .. quadroxalate of pot.

It is also found to extend to combinations of salts and sulphurets (or sulpho-salts.)

Now, if we but for a moment examine these results, we shall perceive that the proportion of oxygen which invariably combines with the substances mentioned is 8, or a multiple of 8; and that the proportions of hydrogen, carbon, and sulphur, are respectively, either 1, 6, and 16, or some multiple of those numbers. We observe also that we may extend the same principle to those bodies which Richter extended to their primary compounds, and Wenzel to the combinations of those compounds. We remarked above, that the quantities of two substances, which by combining together, saturate or neutralize each other, are equivalent in their power of combination; that, for instance, 14.75 grains of sulphate of silver are equivalent to 5 grains of sulphuric acid, those quantities exactly saturating each other. Also, that the quantities of two or more substances, each of which combines with and saturates the same quantity of a third substance, in other words, which are both equivalent to that third quantity, are equivalent to each other: thus, 5 grains of sulphuric acid, and 6.75 grains of nitric acid are equivalents, for they will both combine with and neutralize either 14.75 grains of oxide of silver, or 9.75 grains of barytes; and for the same reason, these two last-mentioned quantities are also equivalents. The term *chemical equivalent*, then, implies that proportion of a body which is necessary to act upon another body, the circumstances of chemical affinity being such as to permit action to take place, it being invariably found that the proportions are always the same for one body, whatever other body it be compared with. Hence, if a particular number be arbitrarily taken to represent the quantity of any one substance which is requisite in order that that substance may be able to enter into combination, and be called its *equivalent*, then the equivalents of other substances may be expressed by numbers, each number bearing the same proportion to the first number, that the combining quantity of the body it represents bears to the combining quantity of the substance to which we have assigned that first number. This was the principle on which Richter proceeded, and by the application of which he formed his table; and a slight examination of the results of combinations which we have given above will show, that by assuming 1 as the arbitrary number, to represent hydrogen, the numbers attached in the following table to those simple substances which occur in those results represent their chemical equivalents; other simple substances are also inserted, which do not enter into the preceding investigations, but whose numbers have been ascertained in a similar manner.

Chemical Equivalents, referred to Hydrogen as 1.

Hydrogen	1	Sulphur	16
Carbon	6	Calcium	20
Oxygen	8	Sodium	24
Lithium	10	Iron	28
Phosphorus	12	Potassium	40
Nitrogen	14	Molybdenum	48

Now we may perceive, that the numbers representing the chemical equivalents of all the above bodies are multiples of that of hydrogen, which is both the lightest body known, and that of which the combining quantity is the smallest; indeed, that they are all multiples of twice that number, and most of them of four times. The same observation is found to apply to the equivalent numbers of all the elementary substances known, although, indeed, according to Berzelius, it fails in one or two instances.

It may, then, be considered as a fact sufficiently established by experiment, that the different proportions in which bodies combine, do follow a numerical law, and the question naturally arises, how this circumstance may be accounted for. This can only be effected on the supposition of matter being divisible into a definite number of ultimate atoms, and consequently furnish an additional argument in favour of that hypothesis; for even if the facts, which we have detailed, be not irreconcilable to the contrary one, they are, at least, in no degree accounted for by them. Be it observed, at the same time, that the truth of the facts in question will not be at all affected, whatever be the manner in which we may attempt to account for them; they are established beyond all doubt.

If matter be infinitely divisible, no reason can be assigned why bodies should unite in certain proportions, and not in others; we should rather expect, that, as their smallest conceivable portions differ in

quantity only, and not in quality, from the largest, they should all possess the same affinities, and that, consequently, the number of combinations taking place between different substances, should be as infinite, as are the parts into which they themselves admit of being separated.

But, on the other hand, if we admit the finite divisibility of matter, and, consequently, the existence of ultimate particles or atoms, we must necessarily suppose that each distinct elementary substance is composed of atoms differing from those of every other substance in point of density or weight, and that the chemical union of bodies is nothing more than a combination between their ultimate atoms. On these suppositions we are enabled to account for the regularity with which those combinations take place. By referring to the table which we have given above, it will be perceived that there are two different combinations of oxygen with hydrogen; of which 1 part, by weight, unites in the one case, with 8 parts of oxygen to form water; and in the other, with 16 parts of oxygen to form deutoxide of hydrogen. Let us suppose, that in the first combination there are the same number of atoms in each of the combining bodies, or that each single atom of the hydrogen unites with each single atom of oxygen; it follows, that the atom of oxygen must be eight times as heavy as the atom of hydrogen, in other words, that the weight of the former must be to that of the latter in the proportion of 8 to 1; for, otherwise, the weights of a collection of the same number of atoms of each would not be in that proportion, which, however, we see is the case. We may account for the second combination, in which the proportion of oxygen is twice as great as in the first, by supposing, in this case, that two atoms of oxygen combine with each single atom of hydrogen. We therefore see, that if it be admitted that the first case of combination is that in which the combining bodies unite atom to atom, it must necessarily follow, that if we represent the weight of the atom of hydrogen, or its atomic weight, by 1, that of oxygen will be 8, and if we call the atomic weight of oxygen 1, we must express that of hydrogen by ⅛, or the corresponding decimal of .125, whichever may be most convenient. But it is by no means certain, from the relative combining weights of these elements, that they do unite atom to atom in the first case of combination; and if they do not, the relative weights of the atom of each, which we have deduced upon that supposition, will not be correct. It is just as possible, that the second case of combination is that in which the substances combine atom to atom; and if we suppose such to be the case, it is evident that the atomic weight of oxygen will be to that of hydrogen in the proportion of 16 to 1; and that we may explain the first case of combination by supposing two atoms of the hydrogen to combine with each single atom of oxygen. These observations may be more conveniently represented in the following manner; it will be apparent that the proportions of the ingredients will be equally well expressed by

2 hyd. + 16 oxy., where 2 atoms hyd. unite with 1 atom oxy.
1 hyd. + 16 oxy., where 1 atom hyd. unites with 1 atom oxy.

as by the mode which we first adopted, and in which we stated the composition thus,

1 hyd. + 8 oxy., where 1 atom hyd. unites with 1 atom oxy.
1 hyd. + 16 oxy., .. 1 atom hyd. .... 2 atoms oxy.

For it will be observed, that the proportion of the elements in each combination is the same in both forms; that denoted by 2 hyd. + 16 oxy. being the same with that expressed by 1 hyd. + 8 oxy. The reason that two different inferences as to the relative weight of the combining substances are drawn from each same proportion, is, as we see, that those inferences are deduced upon certain suppositions, with respect to the mode in which the union takes place; and each combination being liable to two such suppositions, is susceptible of two inferences. Hence, where a substance combines with another in several proportions, all that we are sure of is, that only one of them can represent the atomic weight, and in choosing that one, we must be guided by other considerations derived from a general review of the compounds which it contributes to form. The relative weight of the atoms of oxygen and hydrogen is a subject of disagreement among chemists at the present day, in consequence of some supposing the union between atom and atom to take place in the first combination, or that by which water is formed, and others referring it to the second, or that producing the deutoxide of nitrogen. We have seen that both these suppositions are equally possible; and that the necessary consequence of the one is to establish the relative atomic weights of oxygen and hydrogen to be 8 and 1, that of the other 16 and 1. The latter is the view adopted by Berzelius and Gay-Lussac; the former prevails almost universally among British chemists. Similar differences exist as to other substances, nitrogen, for example. Thus, if we suppose the proportion standing first in the list of combinations of nitrogen with oxygen, which we have given in our table, to be that in which the combining bodies unite atom to atom, the weight of the atom of nitrogen will be represented by 14, and that of oxygen by 8; and in the other combinations the union will take place between 1 atom of nitrogen with respectively 2, 3, 4, 5 atoms of oxygen. But both Berzelius and Mr. Dalton are of opinion, that the most simple of the combinations of nitrogen and oxygen, or that in which they unite atom to atom, is the second in our list, or that producing nitrous gas; and accordingly they infer that the atomic weight of nitrogen is to that of oxygen as 14 to 16, or the latter being 8, the former is 7. The composition of the combinations of those substances will then be as follows:

14 nit. + 8 oxy. nitrous oxide; 2 atoms nit. to 1 atom oxy.
7 nit. + 8 oxy. nitrous gas; 1 atom nit. to 1 atom oxy.
14 nit. + 24 oxy. hyponitrous acid; 2 atoms nit. to 3 atoms oxy.
7 nit. + 16 oxy. nitrous acid; 1 atom nit. to 2 atoms oxy.
14 nit. + 40 oxy. nitric acid; 2 atoms nit. to 5 atoms oxy.

The opposite opinion is, however, that which is more generally maintained; and, according to that, the numbers representing the relative atomic weights of nitrogen and oxygen are 14 and 8. In the determination of the numbers to be used to denote the equivalent quantities of the substances in the table which we have already given, it appeared natural when a substance entered into combination in several proportions, to select the least of them; but as we have seen, particularly in the case of the combinations of oxygen and hydrogen, we were by no means certain that in so doing we should obtain the real combining proportion of that substance, and the one of which all the others were multiples. The determination of the number representing the equivalent, as of that denoting the atomic weight of any sub-

stance, depends entirely upon which of its combinations be considered to be that in which the bodies unite atom to atom; and the same number will stand for both. When a body combines only in one proportion, it is assumed, unless it can be proved to be otherwise, that they unite atom to atom, and hence, that their relative weights will represent those of their atoms. A variety of considerations usually operate to determine the choice of the simplest proportion in which a body combines for the purpose of ascertaining its equivalent quantity or atomic weight, which it would be totally out of place to enter into here on the present occasion; we shall, therefore, only observe, that in Dr. Thomson's elaborate *First Principles*, our readers will find the subject fully investigated in detail.

It is evident, therefore, that with the limitations which we have mentioned, the relative weights of the atoms of all the elementary bodies, as well as their chemical equivalents, may be expressed by a scale of numbers. The same principle may be extended to their compounds; for instance, as we suppose water to be formed by the combination of several atoms of oxygen, uniting atom to atom with an equal number of atoms of hydrogen; the compound, thus formed, must consist of the same number of *compound atoms*, if we may use the expression, every one of which will be composed of one atom of each of the combining bodies; and the weight of the atom of hydrogen being 1, and of that of oxygen 8, the weight of the compound particle of water, or, as by an extension of the meaning of the term, it is called the atomic weight of water, will be 9. For a similar reason, the weight of an atom of deutoxide of hydrogen must be 17; for in this case, for two atoms of oxygen are supposed to unite with every single atom of hydrogen, and the weight of the compound particle of the deutoxide which is thus produced, must therefore be 1 added to twice 8, or 17. In a similar manner, the atomic weight of nitrous oxide will be found to be 22, that of nitrous gas 30, hyponitrous acid 38, nitrous acid 46, and nitric acid 54. Similarly, the relative atomic weight of a compound of any two substances, may be ascertained by adding together the weights of the number of atoms of each, which enter into combination; and this principle will, of course, extend to the combinations of these compounds. For instance, the atom of sulphuric acid, will, by reference to its composition in the table which we have given above, be seen to be 40; and that of potass is 48, this body being formed by the combination of 1 atom of potassium, whose weight is found to be 40, with 1 of oxygen; hence the atomic weight of sulphate of potass is 88, and that of the bisulphate, in the composition of which 2 atoms of sulphuric acid combine with each single atom of potass, must necessarily be 128. In its crystallized form this last salt contains a quantity of water; each particle of it, in fact, is formed by the union together of 2 atoms of acid, 1 of potass, and 2 of water; consequently the atomic weight of the compound must be 146. It will also be perceived, that the same numbers which express the relative atomic weights of two bodies, will also denote their *chemical equivalents*, as we have termed their relative combining weights. For if they represent the comparative weight of atoms, and if bodies combine atom to atom, these numbers must, as already stated, represent the ratio in which bodies combine and saturate each other; hence, indeed, the name *combining weights*, given to them by Dr. Young. Thus, if 16 represent an atom of sulphur, and 1 an atom of hydrogen, and if sulphur and hydrogen unite atom to atom, then 16 parts (whether grains or pounds) of sulphur ought to saturate 1 part of hydrogen, and thus form 17 parts of sulphuretted hydrogen; and the number 17 should also be the atomic weight and combining quantity of that gas. This is true; for we find that 17 parts of sulphuretted hydrogen enter into combination with 56 of sulphuret of potassium. This last number is the atomic weight of sulphuret of potassium, it being composed of an atom of sulphuret, the weight of which is 16, and an atom of potassium, which is 40.

When we speak of the atomic weight of a body, we do not, of course, mean to say that its ultimate atom actually weighs so much, but that the relation which its weight bears to that of the atom of some other body, is expressed by the number used. Consequently we must take some other body as a standard, and assume some number to represent its atomic weight. The choice of both is perfectly arbitrary; Thomson, Wollaston, and Berzelius, refer all substances to oxygen, on account of its capability of combining with every other simple body; and the first assumes its atomic weight to be 1, the second 10, and the third 100. This difference is of little moment, as it merely involves the necessity of expressing in the one case by whole numbers, what is done in the other by fractional parts.

Mr. Dalton, on the other hand, prefers taking hydrogen for his standard, and in this he is followed by a number of other chemists. The advantage is, that all other known bodies being heavier than hydrogen, their atomic weights may be expressed by means of only an ascending scale of numbers. The number assumed as the atomic weight of hydrogen by those who take it for a standard, is 1.

Either of these standards will answer every purpose. In order to convert a number on the hydrogen scale into the corresponding one on the oxygen scale, it is only necessary to divide the former by 8; and if that on the oxygen scale be multiplied by 8, the product will be that of the hydrogen scale. The comparative merits of these two scales must be settled by each person according to the facility he finds in applying them to his purposes; we may however observe that the former would possess a decided advantage, if it should be found to be invariably true, that the combining proportions of all other bodies were multiples of that of hydrogen.

Our limits have compelled us to abstain, in the present article, from many interesting points of inquiry, intimately related to the atomic theory, though not forming an essential part of it; we may instance the principle observed by Guy-Lussac, to regulate the combination by volume of gaseous bodies, and which is termed the law of volumes;—the facts discovered by Mitscherlich, relative to the correspondence existing between the crystalline form of compound bodies and the number of their constituent atoms, which he has denominated *isomorphism*—and the phenomena of *isomerism* and *merorganization*. We shall, however, speak of these on a future occasion. Those of our readers who wish to investigate the subject more fully, we cannot do better than refer to the latest edition (1832) of Dr. Turner's *Elements*; Dr. Daubeny's *Introduction to*

the Atomic Theory, and the before-mentioned work of Dr. Thomson.

Atony; a want of due tension, or a relaxation of the system.

Atra Bilis; a disposition to a dark biliary secretion, usually visible through the whole frame.

Atrip, in nautical language, is applied either to the anchor or sails. The anchor is said to be atrip, when it is partially discharged.

Atrophy is a deficient nourishment of the body. There are many diseases in which the body becomes daily more lean and emaciated, appears deprived of its common nourishment, and for that reason, of its common strength. It is only therefore in those cases in which the emaciation constantly increases, that it constitutes a peculiar disease; for when it is merely a symptom of other common diseases, it ceases with the disease, as being merely a consequence of great evacuations, or of the diminished usefulness or imperfect digestion of the nourishment received. But when emaciation or atrophy constitutes a disease by itself, it depends upon causes peculiar to this state of the system. These causes are,—permanent, oppressive, and exhausting passions, organic disease, a want of proper food or of pure air, exhausting diseases, as nervous or malignant fevers, suppurations in important organs, as the lungs, the liver, &c. Copious evacuations of blood, saliva, &c., are also apt to produce this disease, and on this account, lying-in women, and nurses who are of slender constitution, are often the subjects of this complaint. This state of the system is also sometimes produced by poisons. A species of atrophy takes place in old people, in whom an entire loss of strength and flesh brings on a termination of life without the occurrence of any positive disorder. It is known as the *marasmus senilis,* or atrophy of old people. Atrophy is of frequent occurrence in infancy, as a consequence of improper, unwholesome food, exposure to cold, damp, or impure air, &c., producing a superabundance of mucus in the bowels, worms, obstructions of the mesenteric glands, followed by extreme emaciation, which state of things is often fatal, although the efforts of the physician are sometimes successful, when all the causes of the disease have been previously removed. A local state of the same kind is sometimes produced in single limbs, by palsies, or the pressure of tumours upon the nerves of the limb, &c., and is generally curable by removing the cause.

Attack, in the *Military Art.* Every combat consists of attack and defence: the first, with few exceptions, will always be the most advantageous: hence, an experienced general chooses it, if possible, even in a defensive war. Nothing is more ruinous than to lose its advantage; and it is one of the most important objects to deprive an adversary of it, and to confine him to the defensive. The attack is directed according to the condition and position of the enemy, according to the purpose of the war, according to place, time, and circumstances. Many modes and combinations are allowable. The simplest and most unexpected form will be the best. On the dexterity and courage of the troops, the correct and quick execution of the attack will depend. Those attacks are the best, where all the forces can be directed in concert towards that point of the enemy on which his position depends. If he be beaten at this point, the resistance at others will be without concert or energy. Sometimes it may be of advantage to attack the weakest side of the enemy, if in this way a fatal blow can be given to him; otherwise, an attack at this point is not advisable, because it leads to no decisive results, leaves the stronger points to be overcome afterwards, and divides the force of the assailant. In most cases, the enemy may be defeated if his forces can be divided, and the several parts attacked in detail. The worst form of attack is, that which extends the assailing troops in long, weak lines, or scatters them in diverging directions. It is always unfortunate to adopt half measures, and not aim to attain the object at any price. Instead of saving power, these consume it in fruitless efforts, and sacrifices are made in vain. Feeble assaults and protracted sieges are of this ruinous character. The forms of attack in a battle, which have been used from the earliest times, are thus divided by the tacticians. 1. The parallel, which is the most natural form, and which the troops attacked strive as much as possible to preserve it; for as long as they can do so, they retain their connection and the power of applying their force as occasion may require; but, for this very reason, it is not the best form of attack, because it leaves the defensive party too long in possession of his advantages. 2. The form in which both the wings attack, and the centre is kept back. Where the front of the enemy is weak (the only case in which it is practicable), it appears, indeed, overpowering. 3. The form in which the centre is pushed forward, and the wings kept back, will hardly ever be chosen, on account of several evident disadvantages. 4. The famous oblique mode, where one wing advances to engage, whilst the other is kept back, and occupies the attention of the enemy by pretending an attack. Epaminondas, if not the inventor of this form, knew, at least, how to employ it to the greatest advantage. Whilst the wing which remained behind engaged the attention of the enemy, he increased continually the strength of the one advancing, which he led against the flank of the enemy, with a view of overpowering it by numerical superiority. The success of this mode is almost certain, provided the enemy takes no measures against it. In our times, this form of attack is executed in another way:—whilst engaging the enemy, his flank is surrounded by detached corps, which fall, at the same time, on his rear. If he suffers this quietly, he is vanquished. The enemy's attention is kept occupied, during such operations, mostly by feigned attacks or movements, which are called in general, *demonstrations,* and are intended to keep him in error concerning the real object. Field fortifications are attacked with columns, if possible, from several sides at the same time, and with impetuosity. Commonly, the artillery breaks a way beforehand, destroys the works, and disturbs the garrison.

Attaint, in the *Veterinary Art,* a diseased limb, proceeding from a blow.

Attalicæ Vestes; a species of golden cloth.

Attenuants; a peculiar class of medicines, among which we may particularly place the aromatics, and also the alkaline salts. When viscid humours are to be evaporated from the chest, then elecampane and balsam of Peru may advantageously be employed.

Attenuation; the act of reducing a body into minute particles.

Attic, in *Architecture.* An upper story, or false order, of dwarfish proportions, placed on the summit of a real order, is called an attic story, or an attic

order; probably, because, from concealing the roof, it imitated the buildings of Attica, which were without, or with very flat roofs, for there are no attics existing in the ruins of Athens. In the best ancient examples the attic order or story was generally formed of pilasters, with capitals and entablatures composed without regard to the rules which govern the regular orders. In modern examples, termini, terminial busts, and even caryatides, have been used to form the attic of a building. The Roman architects employed the attic to great advantage over the entablatures of their triumphal arches. The solidity of their forms compensated for the voids below, and formed appropriate pedestals for the chariots and horses with which they were crowned. Their divisions formed also excellent panels for sculpture or inscriptions. If an attic be introduced in an architectural design, it should be so managed as not to appear an after-thought, or that the building had been raised since its first erection; it should bear a just proportion to the other parts, and is better when the building has a proportionate basement or stylobate, than when the columns or antæ of the principal order are standing on the ground. If windows be required, they should be either circles or as nearly square as possible. An oblong parallelogram also looks better in an attic order than a perpendicular aperture of the same dimensions. The attics of Sir William Chambers, at Somerset House, and of Mr. Soane, in the Lothbury Court of the Bank of England, are cited as good examples of attics.

Attic Base. This is a peculiar kind of column, or support, employed both in the Doric and Ionic orders.

Attitude, in *Painting* and *Sculpture;* the position or gesture fitted for the display of some grace, or beauty, or other quality of form. As attitude is of first importance to the artist, and of primary utility in grouping, a knowledge of anatomy is absolutely necessary to prevent the introduction of constrained or impossible attitudes. An attitude may be fixed or transitory, meditated or accidental, and should be applied with propriety to the action represented, or the figure will be unnatural. Attitudes are usually arranged by the aid of a wooden automaton, called a "lay figure." One of the most striking examples of accidental attitude on record, is that of Mr. Nollekin's celebrated bathing figure, justly considered as the best which he ever executed, and which we are informed he derived from his undraped female sitter rising suddenly from a couch, on which she had been sitting in the artist's study. At the end of the last century, the celebrated Lady Hamilton began to practise; and, as every art begins with imitation, she imitated, with great talent, the attitudes of antique statues in many large towns of Europe; and Sir William Hamilton could say that he possessed, in his wife, a whole collection of antiques. Her dress was a simple tunic, fastened with a ribbon tight under the breast, and a shawl. With these she imitated all the different draperies. Mr. Rehberg drew her attitudes, and published them in London. On the continent of Europe, this art has been carried to much perfection by Mrs. Hendel-Schütz, who exhibited the most beautiful attitudes, copied from the Greek, Egyptian, Italian, and German styles of art. But she was not satisfied with imitations: she invented many attitudes, which were declared, by all the critics of the day (amongst whom was Goëthe), some of the finest productions of art. Her attitudes have been drawn and published by Peroux and Ritter (Frankfort, on the Maine, 1809). There has been also a male artist of the same kind, Mr. von Seckendorf (called *Patrick Peale*), who accompanied his exhibitions with lectures. The same sort of exhibition has lately been produced by Mr. Ducrow.

Attollens; a series of muscles sometimes called levatores and elevatores.

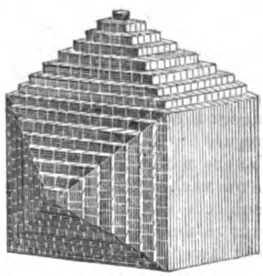
Attraction; the name by which we express the tendency which all bodies invariably have to move towards each other. If two masses of matter be placed at any distance from each other, and be uninfluenced by any external force, they will be observed to move towards each other, as if they each possessed a certain virtue by which it is capable of drawing the other towards it. It is also found that, under the same circumstances, this effect increases as the masses or quantities of matter in the bodies increase. If the quantity of matter be double, the bodies will move towards each other with a double speed: if the quantity of matter be increased in a threefold proportion, the speed of their mutual approach will be also increased in a threefold proportion; and so on. It is likewise found, that the energy of this effect is increased in a certain proportion as the distance between the bodies is diminished; the more closely the bodies approach, the more rapid will be their motions: but this increase of rapidity is not in proportion to the decrease of the distance, but in the proportion of the decrease of what arithmeticians call the square of the distance. This attraction of bodies for one another is called Gravitation, or Gravity, which see. Gravitation, then, may be considered as a power constantly acting at sensible distances upon masses of matter, or visible combinations of the ultimate invisible atoms of bodies. It is a universal property of matter in its operation, and is found to depend upon the *quantity* of matter alone, without regard to its nature. When occurring between bodies which are situated at considerable distances from each other, it is one of the most extraordinary subjects which the human mind can contemplate; and, although the manner in which it operates, and the laws which it follows, are now well understood, it proceeds from secret agencies which the human mind has never yet been able to detect. It is found to exist among all the great bodies of the universe, and to be the power which, restrained by that of inertia, preserves the planetary bodies in their orbits, and presides over their movements; and it is owing to the same general principle that the moon raises the water of the ocean, and forms what we call the tide. We have also numerous instances of it which come more immediately within our own powers of observation. A stone unsupported by the hand is drawn directly to the earth; and a plummet suspended near the side of a mountain inclines towards it in a degree proportioned to the magnitude of the mountain; as Dr. Maskelyne ascertained by a series of experiments upon the mountain Shehalion, in Scotland. If the plummet were let fall near the mountain, it would still fall to the earth, because, although drawn towards the mountain, it is much more strongly drawn towards the earth, the earth containing by far the greater quantity of matter.

When the power of attraction operates at very minute, insensible distances, it is termed Cohesion. It acts upon the ultimate invisible atoms of bodies

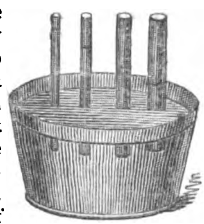
tending to unite them into one mass, and is the power which keeps together the particles of bodies in the state of a solid, and resists any attempt to separate them. The results of attraction, as relating to the texture and forms of matter, are influenced by the circumstances under which it has taken place. Sometimes the particles are, as it were, indiscriminately collected; at others, they are beautifully arranged, giving rise to regular and determinate figures: in this case, bodies of the same composition almost invariably affect the same form; hence, we are often enabled to infer the composition of a substance from accurate inspection of its external or mechanical characters. The regular polyhedral solids thus resulting from the influence of attraction upon certain kinds of matter, are usually called *crystals;* and are said to be produced by the process of *crystallization.*

Hence, it would seem that attraction, in causing the atoms to cohere, so as to form solid masses, seems not to act equally all around each atom, but between certain sides or parts of one, and corresponding parts of the adjoining ones. The fluor-spar of Derbyshire crystallizes in cubes, as does also common salt. Nitre assumes the form of a six-sided prism, and sulphate of magnesia that of a four-sided prism. The basaltic pillars of the Giant's Causeway in Ireland, and in the Isle of Staffa, are natural crystalline arrangements of particles. The observation made by Gahn, that when a piece of calcareous spar was carefully broken, all its particles were of a rhomboidal figure, induced Bergman to suspect the existence of a primitive nucleus in all crystallized bodies.

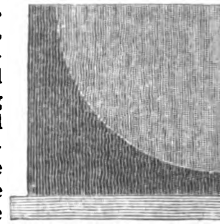
The beautifully symmetrical arrangement which exists naturally in the form of crystalline bodies is shown in the mathematical figure annexed, representing a cube having a series of decreasing layers of cubic particles upon a portion of its faces.



The attraction of cohesion is sometimes attended with a very peculiar effect. If water be poured into a glass vessel and allowed to attain a state of rest, it will be observed to be more elevated at the sides than at the centre, owing to the attraction between the sides of the vessel and the water. If a tube with a very fine bore be immersed in water, the liquid will be elevated in the inside above its level on the outside. This effect takes place because the attraction between the sides of the tube and the water, which tends to draw up the water at the sides, is sufficiently powerful at the same time to lift up that in the middle. If a tube with a bore of half an inch be tried, this effect will not take place, at least to so visible an extent, for the surface presented by the sides of the tube, and consequently its power of attraction, does not increase in the same proportion as the surface of the water. The accompanying illustration will serve to exhibit the ascent of the water in tubes of different bores.



Another mode of exhibiting the effects of capillary attraction may now be adverted to. It consists in the use of two glass plates, hinged together like a book, as is shown in the engraving, and partially separated on one side. On placing the plates in any coloured fluid, it will be found to ascend in a curved line; the fluid rising highest at the side where the plates are nearest, and as such obeying precisely the same law as in the former case.



We have considered attraction as operating in two principal points of view,—at sensible distances on masses or combinations of atoms, of which species is that case to which we have given the name of *gravitation;* and at insensible distances upon the atoms themselves, so as to keep them together in one body. When it operates at insensible distances, to unite particles of different bodies, so that they cannot be separated by any ordinary means it is termed *chemical attraction*, or, simply affinity, and is exemplified in the solution of a lump of sugar or alum in water. For a particular account of its effects, and the laws which they follow, see CHEMISTRY and ATOMIC THEORY.

There are yet two other species of attraction to notice—those of electricity and magnetism. The attraction of electricity is produced by a disturbance of the electrical equilibrium, and is usually exemplified for experimental purposes by rubbing a glass tube, and then bringing it into the neighbourhood of any light pendulous body. The same effects on a large scale, are shown by the electrical machine. See ELECTRICITY.

The attraction of magnetism is exemplified in the approach of iron filings to a magnet; like that of electricity, it acts at sensible distances upon masses, and must therefore be arranged in the same class as gravitation, though so far as we can at present judge, by no means resulting from the same causes. See MAGNETISM.

ATTRACTIVES; a peculiar species of remedies which act by promoting external discharge.

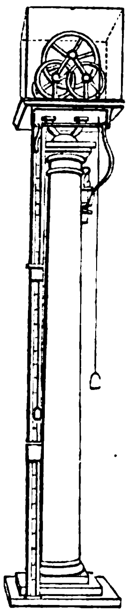
ATTRAENTS; digestive medicines.

ATTRIBUTES; the peculiar properties of bodies. Thus, gravitation is an attribute of matter, whatever be its form. Infinite extension is also, though erroneously, considered an universal attribute.

ATTRIBUTES, in *Painting* and *Sculpture,* mean any adjunct to a figure or group, which is characteristic of the principal subject.

ATWOOD'S MACHINE. A very useful apparatus under this title, employed by the Editor in his public lectures, should have a place in the present department of our work. Its great cost prevents its general use, but it is of the greatest importance for illustrating the doctrine of accelerated motion. The space described, and the acceleration gained by bodies which descend freely towards the earth, has been often attempted to be proved by means of direct experiments; but the resistance of the air, which opposes a considerable and fluctuating impediment, and the difficulty of measuring the time of descent when falling bodies have acquired a great degree of velocity, which soon increases beyond the power of our senses to estimate, have always rendered the re-

sult of such experiments precarious; but by means of the instrument recommended in the accompanying engraving every difficulty is obviated.



It consists of a tall mahogany column, not less than ten feet in height, resting on a base, and supporting a series of friction wheels. The friction wheels again support a large central roller. To the left of the figure is seen a wooden rod, graduated so that the descent of any falling body may readily be indicated in feet and inches.

Now, if we suppose the weights on the opposite ends of the line to be exactly balanced, no motion would occur, as they would be exactly in a state of equilibrium; but if we add, in the slightest degree, to the weight on the left hand, then, by destroying the equilibrium, we shall produce motion, and the body will descend. The weights employed for this purpose are heavy, and but little acted on by the air or any extraneous circumstance; but as the slightest increase of weight will produce motion, we may thus make it apparent to the eye.

Atypos; any thing irregular in its form, either in medicine or anatomy.

Avant-Guard; the corps which precedes the march of an army.

Avante, in the old medical nomenclature, the same with hypochondriasis.

Aubin; a defective gait in a horse.

Auditoria Arteria; the internal auditory artery which goes off from each side of the arteria basilaris to the organ of hearing, and accompanies the auditory nerve, having first furnished several small branches to the membrana arachnorides.

Auditorius Meatus; the passage that conveys the air to the auditory nerve. It leads from the lower anterior part of the concha to the tympanum, and is partly bony, partly cartilaginous: the bony part is the longest, and forms the bottom; the rest is cartilaginous, and makes the external opening or orifice of the canal. These two parts form a canal of about three-fourths of an inch long, slightly tortuous, and wider in some parts than in others. On the membranous covering of the cartilaginous part we observe the yellow bodies, supposed to be the glandulæ ceruminis. The bony part of the meatus is nearly horizontal and straight; the cartilaginous part only is curved and winding, which should be observed when a syringe is used to inject any thing with into the ear.

Auditorius Nervus; the auditory nerve. The seventh pair of nerves are called auditory nerves; so are the sympatheticæ minores. This seventh pair of nerves runs into the os petrosum, and is there divided into the portio mollis, which is spent upon the labyrinth of the ear, and distributed to the auditorius meatus internus, passing to the vestibulum cochleœ, and the portio dura, which goes out by the aqueduct, between the mastoid and styloid processes, passes through the parotid, becomes a cutaneous nerve, and communicates with the upper maxillary. On these nerves, no covering from the dura mater can be traced.

Avellane; an heraldic cross placed on the sovereigns' globe.

Aventuræ; a species of military exercise.

Avenue, in *Architecture;* a way to an access or approach; a long walk of columns, arcades, statues, trees, &c. used for the decoration of an approach to a palace or mansion. The avenue, in the hands of a man of taste, is susceptible of great variety and beauty of design.

Averti, in *Horsemanship*, a regular step or motion.

Auger; an instrument for boring holes.

Auges; two points in a planet's orbit; the one denominated the apogee, the other the perigee.

Augette, in military engineering, the tube for igniting a mine.

Augmented. This term in *Music* means, when applied to a note, an interval of three chromatic degrees.

Augmentation, in *Heraldry*, a particular mark of honour, borne either on an escutcheon, or a canton; as argent, a hand, gules, borne by every baronet who cannot claim higher honour.

Augury was at one time considered a science of the first importance; it has now however taken its proper rank among the absurd superstitions which disgraced the darker, nay, even the most enlightened periods of antiquity. The intestines were generally torn quivering with life from the still sensitive victim, and formed the principal instrument in the hand of the soothsayer or priest. Thanks, however, to the diffusion of general knowledge in every class of society, those disgusting exhibitions of cruelty and priestcraft have now passed away, and we advert to it but as an historical record.

Aulos; a Grecian measure of length equal to the stadium.

Aume; a measure of capacity, employed on the Continent, equal to thirty-five English gallons.

Auncel Weight. This is a term much employed by the old writers. It relates both to the implements for weighing and the mode of effecting a sale. The auncel was a balance with several scale pans, and its use was prohibited by statute. To sell by auncel means with advantage to the dealer.

Aune; a measure of length employed on the Continent. It varies considerably in different parts of Europe. Dr. Kelly, in his *Cambist*, makes it equal to 46.38 English inches. In other parts it is equal to nine-tenths of our ell.

Avoirdupois; a weight having sixteen ounces to the pound, in distinction to Troy weight, which has only twelve. The following is a tabular view of this weight:—

16 drams make	1 ounce.		4 quarters make	1 cwt.
16 ounces	1 pound.		20 cwt.	1 ton.
28 pounds	1 quarter.			

drs.	*ozs.*				
16 =	1 =	*lbs.*			
256 =	16 =	1	*qrs.*		
7168 =	448 =	28 =	1 =	*cwt.*	
28672 =	1792 =	112 =	4 =	1	*ton.*
573440 =	35840 =	2240 =	80 =	20 =	1

5760 Troy grains make 1 pound Troy, and 7000 Troy grains 1 pound Avoirdupois; hence 175 pounds Troy are equal to 144 pounds Avoirdupois.

A very valuable comparative estimate of the relative values of British and Foreign Avoirdupois weights

has been published by Mr. Adcock, of which we may now give the substance.

Names of Places.	AVOIRDUPOIS WEIGHT.	
	Names of Weights.	Number equal to 112lb. Avoird.
Amsterdam	Pound, old weight	102.819
	———, Flemish	50.796
Berlin	Pound	108.421
Bremen	Pound	101.950
Brunswick	Pound	108.798
China	Catty	84.002
Cologne	Pound	108.646
Constantinople	Oke	39.536
Copenhagen	Pound	101.553
England	Pound	112.000
Florence	Libbra	149.609
France	Livre, Poids de Marc	103.771
	Kilogramme	50.796
	Livre Usuelle	101.593
Geneva	Heavy Pound	92.256
	Light Pound	110.709
Genoa	Libbra, Peso Grosso	145.697
	Libbra, Peso Sottile	160.261
Hamburg	Pound	104.868
Hanover	Pound	104.378
Leghorn	Libbra	149.609
Lyons	Livre, Pois de Soie	110.617
	Livre, Pois de Table	118.518
Naples	Cantaro Grosso	56.997
	Cantaro Piccolo	105.660
Netherlands	New Pound	50.796
Persia	Batman of Cherray	88.316
	Batman of Tauris	176.634
Poland	Cracow Pound	125.440
	Warsaw Pound	134.430
	New Pound	125.721
Portugal	Arratel	110.687
Prussia	Pound	108.617
Riga	Pound	121.512

Aura signifies an exhalation or vapour. The old chemists mean by it a certain fine and pure spirit, found in every animal and vegetable body; but so subtle as only to be perceptible to us by its smell.

Aurea Alexandrina, in *Pharmacy*, a compound opiate confection, much in repute among the ancient physicians. It was considered as a powerful alexipharmic, or antidote to poison.

Aurens; an ancient gold coin, varying very much in its value in different parts of the Roman empire, equal to about eighty sesterces.

Auriculæ Judæ is a sort of fungus, which grows on elder trees. Its internal use is hardly considered safe, but a decoction in milk has been much esteemed as a gargle in cases of quinsey.

Auricula; the external part of the ear, which is divided into the upper part, called pinna, and the lower soft part, called lobus, or lobulus. The pinna is divided into several eminences and cavities: the eminences are the helix, called also capreolus; antihelix; tragus, called also antilobium; and antitragus. The helix is the large border round the ear, or the exterior compass of the ear: so called because of its tortuosity. The anti-helix is the large oblong eminence surrounded by the helix. The tragus is the like anterior protuberance, opposite to the lobe, below the fore part of the helix, which in the aged is often covered with hairs. The anti-tragus is the posterior protuberance below the inferior extremity of the anti-helix; the name of a muscle which acts only upon the cartilage of the ear.—The cavities are the scapha, on the inside of the helix; the cavitas innominata, or fossa navicularis, at the anterior upper part of the anti-helix; the concha, which is situated under the anti-helix, divided by a septum, which is a continuation of the helix; and the meatus auditorius externus.

The auricula is composed chiefly of cartilage, which gives and preserves its shape. It has the advantage of being variable, for there are certain small muscles, called helicalis major and minor, tragicus, and anti-tragicus, which are peculiar to the ear; they act only upon the cartilage, and contribute to direct it towards sound; or, by giving a greater tension, to increase its intensity.

The external ear is fixed to the cranium, not only by the cartilaginous portion of the meatus, but also by the ligaments, viz. the anterior, which is fixed by one extremity to the root of the apophysis zygomatica of the os temporis, close to the corner of the glenoid cavity, and by the other extremity to the anterior and superior part of the cartilaginous meatus. The posterior ligament is fixed by one end to the root of the mastoid apothysis, and by the other to the posterior part of the convexity of the concha, so that it is opposite to the anterior ligament. There is also a kind of superior ligament, which seems to be only a continuation of the aponeurosis of the frontal and occipital muscles.

Auricolla, a substance with which goldsmiths solder gold.

Auriga, in *Astronomy*, the Waggoner; a constellation in the northern hemisphere. In Ptolemy's Catalogue there are 14 stars numbered; in Tycho's, 27; in Helvelius's, 40: in the Britannic Catalogue, 66. This is one of the 48 asterisms, mentioned by all the ancient astronomers; and is represented by the figure of an old man in a kind of sitting posture, with a goat and her kids in his left hand, and a bridle in his right. Besides the Hoedi, this constellation includes another of the stars which the ancients distinguished by peculiar names, that is, Capella, and Almathœa Capra, which is the bright one near the shoulder, and supposed to be the mother of the Hoedi, and the nurse of Jupiter. The Hoedi, or the two stars in the arm of Auriga, were regarded by the ancients as affording presages of the weather: and they were so much dreaded, on account of their power over storms and tempests that succeeded their rising, that they were said to shut up the navigation of the sea at this season. When the day of their peculiar influence was passed, the ancients celebrated a festival with sports and games, under the denomination of "Natalis Navigationis." Germanicus calls them stars unfriendly to mariners; and Virgil joins them with Arcturus, mentioning their setting and rising as circumstances of the most important presage. To the same purpose all the ancient critics represent a part of the constellation Auriga, if not the whole of it, as deserving particular attention, and as much an object of terror as the blazing Arcturus.

Aurigraphus; an illuminator, or writer in golden characters.

AURIS; the term by which anatomists express the ear. The ear is usually divided into the external and internal. By the external, is meant all that lies without the external orifice of the meatus auditorius in the os temporis. By the internal, all that lies within the cavity of this bone; the orifice of which is called cyar. The arteries of the external ear come anteriorly from the arteria temporalis, and posteriorly from the occipitalis. The veins are branches of the external jugulars. The portio dura of the auditory nerve having passed out of the cranium through the foramen stylo-mastoidæum, gives off a branch, which runs up behind the ear. The second vertebral pair send also a branch to the ear, the ramifications of which communicate with those of the other branch from the portio dura. The bones of the ear, called malleus, incus, orbiculare, and stapes, are placed in the cavity of the tympanum, immediately on the inside of the membrana tympani. The malleus is joined by its handle to the membrana tympani, and its round head rests on the incus, the long leg of which rests on the os orbiculare, which is fixed to the fore part of the stapes, the sole of which rests on the hole called fenestra ovalis.

The use of the external ear is to collect sounds, and to render their impression on the other organs of hearing most perfect. This is evident from those who have their ears cut off being obliged to use a horn, or some other means to assist them in hearing: all animals, as deer, hares, &c. whose ears have much motion, always direct them so as to meet the sound. See EAR, SOUND, and ACOUSTICS.

AURISCALPUM; a surgical instrument employed to operate on the ear.

AURORA BOREALIS, or Northern Lights. We often see in the north, near the horizon, usually a short time after sunset, a dark segment of a circle, surrounded by a brilliant arch of white or fiery light; and this arch is often separated into several concentric arches, leaving the dark segment visible between them. From these arches, and from the dark segment itself, in high latitudes, columns of light, of the most variegated and beautiful colours, shoot up towards the zenith, and, sometimes, masses like sheaves of light are scattered in all directions. The appearance is then splendid; and its increasing beauty is announced by a general undulation of the masses of light. A kind of fiery coronet is afterwards formed about the zenith, by the meeting of all the columns of light, resembling the knob of a tent. At this moment the spectacle is magnificent, both for the multiplicity and beauty of the columns which the aurora presents. (See Maupertuis *De la Figure de la Terre*, Paris, 1738.) The light, after this, grows fainter and more tranquil. This faintness and tranquillity, however, are only temporary, for the phenomena are soon repeated in all their beauty—the oscillation of the columns of light, the formation of the corona, and the like, though with a thousand variations. At length, the motion wholly ceases, the light is collected about the northern horizon, the dark segment vanishes, and nothing is left but a strong brightness in the north, which is lost in the dawning day. These brilliant appearances are also attended, in high latitudes, with loud noises, described as resembling the hissing and crackling of fire-works. This appearance has received the name of *northern light*, because, on account of our position on the earth, we see it only about the north pole. A similar appearance, *aurora australis*, was seen about the south pole, in 1773, by Cook's sailors, between 58° and 60° S. lat., and later travellers have observed the same. These phenomena ought, therefore, properly to be called *polar lights*. Philosophers are of different opinions as to the cause of the aurora. It is, however, satisfactorily ascertained to be within the region of our atmosphere. The satisfactory demonstration of the agency of electricity in the production of thunder and lightning, has occasioned the application of its principles to the solution of other phenomena, and in some instances it applies more plausibly than any other existing explanation. Such is particularly the case with some of those luminous appearances that occasionally enliven our atmosphere; effects which have always been, and still continue amongst its most mysterious phenomena.

The aurora borealis, or northern light, is a phenomenon of this kind, whose appearance so exactly resembles some of the effects of artificial electricity, that those who have had the opportunity of comparing it with them, can entertain no doubt that their causes are identical. When electricity passes through rarefied air, it exhibits a diffused luminous stream, which has all the characteristic appearances of the northern lights. There is the same variety of colour, and intensity; the same undulating motion, and occasional corruscations; the streams exhibit the same diversity of character, at one moment minutely divided in ramifications, and at another beaming forth in one body of light, or passing in distinct broad flashes; and when the rarefaction is considerable, various parts of the stream assume that peculiar glowing colour which occasionally appears in the atmosphere, and is regarded by the uninformed observer with astonishment and fear. There is, therefore, little doubt that the natural phenomenon is occasioned by the passage of electricity through the upper regions of the atmosphere. The lowest estimate that has been made of the distance from the earth's surface at which it occurs, is that of Mr. Cavendish, who states that distance to be 71 miles; now, at 70 miles, the air is 1,048,576 times more rare than at the surface of the earth; and this is a degree of rarefaction beyond the power of any air-pump yet constructed. These circumstances tend almost to a demonstration, that the light of the aurora is produced by the same means as the light of electricity; but there are other characteristics of that remarkable phenomenon that still remain unexplained.

Dr. Halley has described very fully the appearance of a remarkable aurora, and has collected together a variety of observations that may serve as a history of its phenomena; he ascribed its production to the same influence as that which causes magnetism; and the observations of Mr. Dalton prove that the luminous beams of the aurora is really that of the dipping-needle. Signior Beccaria conceives that the phenomena of magnetism are occasioned by a constant natural circulation of the electric fluid from north to south, originating from several sources in the northern hemisphere. The aberration of the common centre of these currents from the north point, he supposes, may cause the variation of the needle; the period of this declination from the centre may be the period of the variation; and the obliquity of the current the cause of the dip of the magnetic needle.

The northern lights are at present very rarely

visible here; about thirty years since they were frequently observed, and on one occasion their appearance was remarkably brilliant, and has been minutely noticed by Mr. Dalton. An extract from his description will convey a general idea of an effect we have but rarely an opportunity to observe.

"Attention was first excited by a remarkable red appearance of the clouds to the south, which afforded sufficient light to read by, at eight o'clock in the evening, though there was no moon, nor light in the north. Some remarkable appearance being expected, a theodolite was placed to observe its altitude, bearing, &c.

"From 9½ to 10 P. M., there was a large, luminous, horizontal arch to the southward, almost exactly like those we see in the north; and there was one or more concentric arches northward. It was particularly noticed, that all the arches seemed exactly bisected by the plane of the magnetic meridian. At half-past 10 o'clock, streamers appeared very low in the S. E., running to and fro, from W. to E.; they increased in number, and began to approach the zenith, apparently with an accelerated velocity; when, all on a sudden, the whole hemisphere was covered with them, and exhibited such an appearance as surpasses all description. The intensity of the light, the prodigious number and volatility of the beams, the grand intermixture of all the prismatic colours in their utmost splendour, variegating the glowing canopy with the most luxuriant and enchanting scenery, afforded an awful, but at the same time the most pleasing and sublime spectacle in nature. Every one gazed with astonishment; but the uncommon grandeur of the scene only lasted about one minute; the variety of colours disappeared, and the beams lost their lateral motion, and were converted, as usual, into the flashing radiations; but even then it surpassed all other appearances of the aurora, in that the whole hemisphere was covered with it.

"Notwithstanding the suddenness of the effulgence at the breaking out of the aurora, there was a remarkable regularity in the manner. Apparently, a ball of fire ran along from east to west, and the contrary, with a velocity so great as to be barely distinguishable from one continued train, which kindled up the several rows of beams one after another: these rows were situate before each other with the exactest order, so that the bases of each row formed a circle crossing the magnetic meridian at right angles; and the several circles rose one above another in such sort, that those near the zenith appeared more distant from each other than those near the horizon, a certain indication that the real distances of the rows were either nearly or exactly the same. And it was farther observable, that during the rapid lateral motion of the beams, their direction in every two nearest rows was alternate, so that whilst the motion of one row was from E. to W., that in the next was from W. to E.

"The point to which all the beams and flashes of light uniformly tended, was in the magnetic meridian, and as near as could be determined, between 15 and 20 degrees of the zenith. The aurora continued, though diminishing in splendour, for several hours. There were several meteors (falling stars) seen at the time; they seemed below the aurora, and unconnected therewith."

When the northern lights are visible in this country, they are said to appear chiefly in the spring and autumn, and usually after a period of dry weather; they do not refract the light of the stars, which are often distinctly seen through the luminous arch or beams. They are seen more rarely in countries nearer the equator, but occur almost instantly during the long winters, in the polar regions, and with a lustre of which we can form but a faint conception.

In the Shetland isles they are called "merry dancers," and are the regular attendants of clear evenings, giving a diversity and cheerfulness to the long winter nights. Their first appearance is at twilight, just above the horizon; they have at first no particular brilliance or motion; but, after some time, break forth into streams of refulgent light, whose Protean columns gradually assume every possible variety of form and shade of colour; frequently covering the whole visible hemisphere; which then presents the most brilliant spectacle imagination can conceive.

In Hudson's Bay, the refulgence of the aurora is stated to be frequently equal to that of the full moon. In the northern latitudes of Lapland and of Sweden, their brilliance is so remarkable and constant, as to enliven the path of the traveller during the whole night. In the north-eastern parts of Siberia they are also described as moving with incredible velocity; and clothing the sky with a most brilliantly luminous appearance, "resembling a vast expanded tent, glittering with gold, rubies, and sapphires." This phenomenon is said to be accompanied by a loud hissing or crackling noise, so terrific, that when the fox-hunters, on the confines of the icy sea, are overtaken by it, their dogs lie close to the ground, and refuse to move until the noise has passed. That a noise of this kind occasionally accompanies the northern lights, has been testified by several observers, and amongst others, Mr. Nairne and Mr. Cavallo; the last says, he has heard it distinctly on several occasions. This effect is the most extraordinary of all that accompany this phenomena, and if established as a fact, is perfectly unaccountable; for, from the extent of the country over which the aurora is frequently seen, it is certain that it must occur at a very considerable height above the earth's surface; and though the calculations on this subject differ remarkably, yet the very lowest estimate gives an elevation, at which, according to the known principles of philosophy, there exists no medium capable of transmitting sound.

An aurora has been sometimes observed near the south-pole, which seems to favour Beccaria's idea, that its cause is the circulation of a fluid. Its appearance is similar to that of the northern light, but without the same diversity of colour.

The beams of the aurora appear to converge towards the zenith, and their summits seem narrower than their bases; but this, as was observed by Dr. Halley and Mr. Cavendish, is merely an optical illusion; and it has been shown by Mr. Dalton, that the beams are really cylindrical, and parallel to each other; and that the distance of their bases from the earth, is equal to, or probably greater than, the length of the beams; and he has calculated that these beams are 75 miles long, and 7½ miles diameter.

AURUM; gold, the most valuable of all the metals. It is of a reddish-yellow colour, soft texture, not sonorous, but exceedingly ductile and malleable. (See GOLD.)

AURUM POTABILE; tincture of gold, a cordial liquor with leaf gold in it.

AURUM FULMINANS; thundering gold, a precipitate of gold, so called because of the explosion which it makes by a gentle attrition.

AURUM HORIZONTALE; a mercurial medicine of a red colour.

AURUM MOSIACUM, or MUSICUM; a composition to lay on a colour like brass or copper.

AUSTER; the south wind.

AUSTERE is in general applied to a rough astringent taste, united with that of sourness. It is identical with acerbi.

AUSTRAL SIGNS; the six last signs in the zodiac, so called because they are on the south side of the equinoctial.

AUSTRALIS PISCES; a constellation of the southern hemisphere, being one of the forty-eight constellations mentioned by the ancients, not visible in our latitude. The stars in Ptolemy's Catalogue are 18; and in the Britannic Catalogue 24. Formahaut, a star of the first magnitude, is in the mouth of this fish.

AUSTRALIZE; a disposition to point towards the south; and as opposite magnetic poles attract each other, it will be obvious that what we call the north pole of the magnet, is the austral or southern pole.

AUSTRO AFRICUS, in *Meteorology*, the south-southwest point, or wind.

AUTOMATON. Under the article ANDROIDES, our readers will find an account of a very curious and perfect automaton, and we now purpose continuing our account of self-moving machines. In the first place, however, it may be advisable to notice some of the earlier attempts at constructing automata. The flying dove of Archytas, mentioned by Aulus Gellius, is the earliest self-moving engine of which we have any record; and this, as well as the flying chair of Dr. Hook, may, in all probability, be classed with the speaking head of Friar Bacon, and the no less wonderful impositions contrived by the dealers in oracles during the darker ages of the world. Coming, however, to a later period, we find that Louis XIV. was passionately fond of automata, and devoted the early years of his life to their construction. One piece of apparatus constructed by this ingenious scion of royalty, is worthy of record.

It represented a lady proceeding to court, in a small chariot drawn by two horses, and attended by her coachman, footman, and page. When the machine was placed at the end of a large table, the coachman smacked his whip, the horses started off with all their natural motions, and the whole equipage drove on to the farther extremity; it would now turn at right angles in a regular way, and proceed to that part of the table opposite to that which the prince sat, when the carriage stopped, the page alighted to open the door, and the lady came out with a petition, which she presented with a curtsey to the bowing young monarch; the return was equally in order. After appearing to attend the prince for a short time, the lady curtsied again, and re-entered the chariot, the page mounted behind, the coachman flourished his whip, and the footman, after running a few steps, resumed his place.

M. Droz, of La Chaux de Fonds, in the province of Neufchatel, also executed some curious pieces of mechanism. One of these was a clock, presented to the king of Spain, to which pertained, among other curious contrivances, a sheep that imitated the bleating of that animal, and a dog, watching a basket of fruit, that barked and snarled when any one offered to take it away, and a variety of moving human figures. Mr. Collinson informs us, that when he was at Geneva, Droz, the son of the former, showed him an oval gold snuff-box, about 4½ inches long, 3 broad, and 1½ thick, which was double, with an horizontal partition; one of the partitions contained snuff, and in the other, upon opening the lid, there sprang up a very small bird, of green enamelled gold, perching on a gold stand. This minute curiosity, being only three-quarters of an inch from the beak to the extremity of the tail, moved its body, shook its wings, opened its bill of white enamelled gold, and poured forth such a clear, melodious song, as would have filled a room, of twenty or thirty feet square, with its harmony. Another automaton of Droz's was the figure of a man, about the natural size, which held in its hand a metal style; and, by touching a spring that released the internal clockwork from its stop, the figure began to draw on a card of Dutch vellum laid under the style. Having finished its drawings on the first card, the figure rested. It then proceeded to draw different subjects on five or six other cards, which number limited its delineating powers.

To furnish our readers with a notion of the amazing accuracy with which automata may be made to delineate figures, and, indeed, perform the part of mechanical draftsmen, we annex a fac-simile of a drawing, in the possession of Mr. Fillinham, which was actually executed by an automaton figure exhibited in London.

We cannot dismiss the subject of automata without adverting to the fact that nearly all those which have yet been made for exhibition, are much fitter for the amusement of children, than as furnishing recreation for thinking beings. Of a far different character are those employed for weaving, and other mechanical manipulations. They have served to raise this country to a degree of commercial wealth, which has enabled her to fight the battles of freedom in every part of the civilized world.

AUTOPHOSPHORUS, see PHOSPHORUS.

AUTOPYRITES; a species of bread described by Galen. The word is only found in the very early books on medicine.

AUTUMN; that one of the seasons which, in the northern temperate zone, begins when the sun, in its apparent descent to the southern hemisphere, touches the equator. The end of autumn is at the time of the sun's greatest south declination, or when he enters Capricorn. According to our computation of time, the beginning of autumn is Sept. 23, when, for the second time in the year, the days and nights are

equal; and the end is Dec. 21, at the time of the shortest day. The autumn of the southern hemisphere takes place at the time of our spring. From this astronomical autumn the physical or popular autumn differs according to the climate.

AUTUMNAL EQUINOX, see EQUINOX.

AUTUMNAL POINT is called, by astronomers, that point where the equator cuts the ecliptic: the sun reaches it Sept. 23. It is said to be at the beginning of Libra, and is continually marked so, notwithstanding the point has long since receded from this constellation, and is now near the stars of the left shoulder of Virgo. It is opposite to the vernal point; therefore its ascension amounts to 180°, and its longitude also to as many, or six signs; its declination and latitude $= 0$.

AUX; an astronomical term employed to describe a portion of the ecliptic.

AWL; a sharp-pointed implement formed of the best steel.

AWME, see AUME.

AWN *of wine*, a measure which does not occur in modern commercial transactions, but is stated in the dictionaries to be equal to 360 pounds.

AWNING, on board a ship, is when a sail, a tarpauling, or the like, is hung over any part of the vessel, above the decks, to keep off the sun, rain, or wind. Awnings are made of canvass. The length of the main-deck awning is from the centre of the fore-mast to the centre of the main-mast and fore-mast. The length of the quarter-deck awning is from the centre of the main-mast to the centre of the mizen-mast; and the width answers to the breadths of the ship, at the main-mast, mizen-mast, and at the midway between. The length of the poop, or after-awning, is from the centre of the mizen-mast to the ensign-staff, about seven feet above the deck. The canvass is cut to the given breadths of the awning, allowing a few inches to hang down on each side, which is sometimes scolloped and bound. Half the diameter of the masts is cut out in the middle at each end, and lacing-holes are made across the ends, to connect one awning to another. Sometimes curtains are made to hang to the sides of the awnings, of the same length as the awnings. Their depth is taken from the sides of the awning to the gunwale. The seams and tablings are the same as those of the awnings, and lacing-holes are made along the upper tabling of the curtain, and the side tabling of the awning.

In the long-boat they make an awning, by bringing the sail over the yard and stay, and booming it out with the boat-hook.

On shore, awnings are made of common canvass; and if they be frequently wetted, ice may be preserved between them and the damp earth—so powerful is the refrigirating power of the evaporation.

AXAMENTA; choral harmony without instrumental accompaniment.

AXE; a large sized hatchet. It is much employed by the Indian tribes for the purposes of war, and many hundreds of these destructive implements have lately been manufactured in Birmingham to be sent with the "fire water" (*Anglicè*, ardent spirits), for the purpose of civilizing the aboriginals in America.

AXILLA; the arm-pit. There is a peculiar secretion from this part of the body, which in many persons is highly offensive. It is affirmed, that a cure may be effected by the use of a decoction of wild artichoke in wine.

AXILLARY ARTERY, see SUBCLAVIAN.

AXILLARY GLANDS; secreting glands beneath the arm-pits.

AXILLARY NERVE. This nerve passes beneath the arm-pit, and joins the cervical series.

AXILLARY VEIN. This, like the preceding, takes its name from the arm-pit, beneath which it runs, and dividing itself into branches, supplies the whole neighbourhood.

AXILLARY VERTEBRÆ. The second in the downward series of bones.

AXIOM, a self-evident truth, or a proposition whose truth every person receives at first sight; and to which the term is applied, par excellence, on account of its importance in the process of reasoning. Axioms are self-evident truths that are necessary, and not limited to time and place, but must be true at all times and in all places.

Thus, that the whole is greater than a part; that it is impossible for a thing both to be and not to be, at the same time; and that from nothing, nothing can arise, are axioms,

By axioms, called also maxims, are understood all common notions of the mind, whose evidence is so clear and forcible, that a man cannot deny them without renouncing common sense and natural reason.

Self-evident proportions furnish the first principles of reasoning; and it is certain, that if in our researches we merely employ such principles as these, and apply them properly, we shall be in no danger in advancing from one discovery to another. For this we may appeal to the writings of mathematicians, which being conducted agreeable to this standard, incontestably prove the stability of human knowledge, when it is made to rest on so sure a foundation. The propositions of this kind of science, have not only stood the test of ages; but they are found to be attended with that invincible evidence, which constrains the assent of all who consider the proofs by means of which they are established.

Lord Bacon proposes a new science, to consist of general axioms, under the denomination of *philosophia prima*.

Axiom is also an established principle in some art or science. Thus, it is an axiom in physics that Nature does nothing in vain; that effects are proportional to their causes, &c. So it is an axiom in geometry, that if to equal things you add equals, the sum will be equal, &c. It is an axiom in optics, that the angle of incidence is equal to the angle of reflection and refraction. In this sense the general laws of motion are called axioms; as that all motion is rectilinear, and that action and reaction are equal.

These particular axioms, it may be observed, do not immediately arise from any first notions or ideas, but are deduced from certain hypotheses; this is particularly observable in physical matters, in which, as several experiments contribute to make one hypothesis, so several hypotheses contribute to one axiom.

The axioms of Euclid are very general propositions, and so are the axioms of the Newtonian philosophy; but these two kinds of axioms have very different origins. The former appear true upon a bare contemplation of our ideas; whereas the latter are the result of the most laborious induction. Lord Bacon, therefore, strenuously contends, that they should never be admitted upon conjecture, or even upon the

authority of the learned; but, as they are the general principles and grounds of all learning, they should be canvassed and examined with the most scrupulous attention.

A modern writer distinguishes between axioms intuitive, and self-evident. The former, he says, pass through the first inlets of knowledge, and flash direct conviction on the minds, as external objects do on the senses, of all men; in the formation of the the latter, reason judges by single comparisons, without the aid of a third idea or middle term; so that they have their evidence in themselves, and though inductively framed, they cannot be syllogistically proved. If we admit this distinction, and its reasonableness must be allowed, the character of intuitive axioms will be restricted to particular truths.

Axis, in *Anatomy*, the second vertebræ of the neck.

Axis, in *Geometry*, the straight line in a plane figure, about which it revolves, to produce or generate a solid. Thus, if a semi-circle be moved round its diameter at rest, it will generate a sphere, whose axis is that diameter; and if a right-angled triangle be turned about its perpendicular at rest, it will describe a cone, whose axis is that perpendicular. The term axis is yet more generally used for a right line conceived to be drawn from the vertex of a figure to the middle of the base.

Axis *of a Circle or Sphere*, is any line drawn through the centre, and terminated at the circumference on both sides.

Axis *of a Cylinder*, is the line from the centre of the one end to that of the other.

Axis *of a Conic Section*, is the line from the principal vertex, or vertices, perpendicular to the tangent at that point. The ellipse and hyperbole have each two axes, which are finite and perpendicular to each other; but the parabola has only one, and that infinite in length. Transverse axis, in the ellipse and hyperbola, is the diameter passing through the two foci, and the two principal vertices of the figure. In the hyperbole it is the shortest diameter, but in the ellipse it is the longest. Congregate axis, or second axis, in the ellipse or hyperbola, is the diameter passing through the centre, and perpendicular to the transverse axis, and is the shortest of all the conjugate diameters. Axis, of a curve line, is still more generally used for that diameter which has its ordinates at right angles to it, when that is possible. For, as in conic sections, any diameter bisects all its parallel ordinates, making the two parts of them on both sides of it equal; and that diameter which has such ordinates perpendicular to it, is an axis: so, in curves of the second order, if any two parallel lines each meeting the curve in three points; the right line which cuts these two parallels so, that the sum of the two parts on one side of the cutting line, between it and the curve, is equal to the third part terminated by the curve on the other side, then the said line will in like manner cut all other parallels to the former two lines, viz., so that of every one of them, the sum of the two parts, or ordinates, on one side, will be equal to the third part or ordinate on the other side. Such cutting line then is a diameter; and that diameter, whose parallel ordinates are at right angles to it, when possible, is an axis. And the same for other curves of still higher orders.

Axis, in *Astronomy*. As the axis of the world is an imaginary right line conceived to pass through the centre of the earth, and terminating at each end in the surface of our sphere, about this line, as an axis, the sphere, in the Ptolemaic system, is supposed daily to revolve.

Axis *of the Earth*, is the line connecting its two poles, and about which the earth performs its diurnal rotation, from west to east. This is a part of the axis of the world, and always remains parallel to itself during the motion of the earth in its orbit about the sun, and perpendicular to the plane of the equator.

Axis *of a Planet*, is the line passing through its centre, and about which the planet revolves. The Sun, Earth, Moon, Jupiter, Mars, and Venus, it is known from observation, move about their several axes; and the like motion is easily inferred of the other three, Mercury, Saturn, and Georgian planet.

Axis *of the Horizon*, *Equator*, *Ecliptic*, and *Zodiac*, are right lines passed through the centres of those circles, perpendicular to their planes.

Axis *of a Magnet*, or *Magnetical Axis*, is a line passed through the middle of a magnet lengthwise; so that, however the magnet be divided, provided the division be made according to a plane passing through that line, the magnet will then be cut into two loadstones. And the extremities of such lines are called the poles of the stone.

Axis, in *Mechanics*. The axis of a balance or cylinder is the line upon which it moves or turns.

Axis *of Oscillation*, is a line parallel to the horizon, passing through the centre, about which a pendulum vibrates, and perpendicular to the plane in which it oscillates.

Axis *in Peritrochio*, or *Wheel and Axle*, is one of the mechanical powers, or simple machines, contrived chiefly for the raising of weights to a considerable height. See Mechanics.

Axis *of a Vessel*, is that quiescent right line passing through the middle of it, perpendicular to its base, and equally distant from its sides.

Axis, in *Optics*. The optic axis, or visual axis, is a ray passing through the centre of the eye, or falling perpendicularly on the eye.

Axis *of a Lens*, or *Glass*, is the axis of the solid of which the lens is a segment. Or the axis of a glass, is the line joining the two vertices or middle points of the two opposite surfaces of the glass.

Axis *of Incidence*, in *Dioptrics*, is the line passing through the point of incidence, perpendicularly to the refracting surface.

Axis *of Refraction*, is the line continued from the point of incidence or refraction, perpendicularly to the refracting surface, along the farther medium.

Axle, see Axis.

Axungia; the old name for hogs'-lard.

Axungia Vitri Sandiner; a salt of glass procured during fusion.

Azarum; a medicinal root employed as a specific for the farcy in horses.

Azed; another name for the large Camphor, which see.

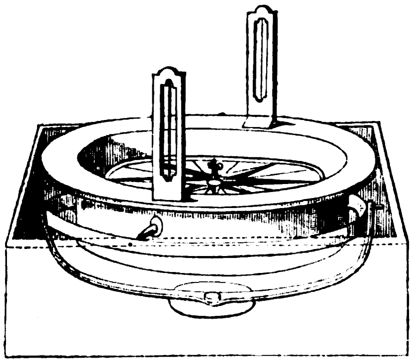
Azelfoge, in *Astronomy*, a fixed star of the second magnitude, in the Swan's Tail.

Azemech, in *Astronomy*, see Virgin's Spike.

Azimuth; an arc of the meridian, comprehended between the meridian of the place, and the azimuth circle, passing through the sun, &c.

Azimuth Circles; great circles of the spheres, intersecting each other in the Zenith and Nadir.

Azimuth Compass. The common compass, when provided with sights, may be converted into this instrument. The sights are so placed that the sun may be seen, in order to find its amplitude or azimuth. Whence the declination of the magnetic meridian from the true or astronomical meridian may be determined; those two meridians seldom coinciding.



An instrument of this description is represented in the accompanying figure, in which the sight-plates ascend perpendicularly, being furnished with a perpendicular thread or wire through the middle The ring of the gimbals rests with its pivots on the semicircle beneath, the foot of which turns in a socket, so that whilst the box remains steady, the compass may be turned round, in order to place the sights in the direction of the sun, or other celestial object. The pivots of the gimbals of this, as well as of the steering compass in general, should lie in the same plane with the point of suspension of the needle or card, for the purpose of avoiding the irregularity of its vibrations as much as possible. In the inside of the box there are two lines drawn on its sides perpendicularly down, from the points where the thread touches the edge of the box. These lines serve to show how many degrees the north or south pole of the needle is distant from the azimuth of the sun; on which account the middle of the apertures in the sight vanes, the thread, and the above-mentioned two lines must stand exactly in the same vertical plane. The use of the thread, which is sometimes omitted in compasses of this sort, is to show the degrees between the magnetic meridian and the azimuth, &c., when the eye of the observer stands perpendicularly over it. On one side of the box of the azimuth compass, there is generally a nut or stop, which, when pushed in, bears against the card and stops it; and this is done for the purpose of reading that degree, half-degree, &c., of the card which coincides with one of the perpendicular lines in the inside of the box.

Azimuth Dial; a dial whose stile or gnomon is perpendicular to the plane of the horizon.

Azoga Ships (from the Spanish *azogue*, quicksilver) were those Spanish ships, commonly called the *quicksilver ships*, from their carrying mercury to the Spanish West Indies, to extract the silver from the mines of Mexico and Peru. They were prohibited from carrying any goods except for the king of Spain.

Azote, or Nitrogen, is a permanently elastic gas, transparent, colourless, and inodorous. Its specific gravity is 0.9748; and 100 cubic inches of it weigh 30.0355 grains.

A number of processes have been given in chemical books for the preparation of azote, but they are tedious or troublesome, or both. The following is the method recommended by Mr. Donovan in his excellent work on Chemistry. Take a bottle, capable of containing a gallon (277¼ cubic inches), and fit a cork accurately to it: throw into it 22 troy drachms of the salt sold by druggists under the name of green copperas, or sulphate of iron, with half a pint of water; then pour as much water on 4½ drachms of roche lime as will slake it; and when slaked, throw it into the dissolved sulphate of iron. Cork the bottle perfectly close; and, having inverted it, immerse the neck in a vessel of water, to prevent the entrance of air. By agitating this mixture briskly during a few minutes, still keeping the neck immersed, the whole of the oxygen present in the common air, which the bottle had contained, will be absorbed; and, on removing the cork under water, a quantity of water will rush in, equal to the volume of oxygen which had been removed. The air now remaining in the bottle is pure azote; its volume is 222 cubic inches, and it may be transferred into any other vessel, by filling that vessel with water, inverting it so, that the mouth shall be in water, then getting the mouth of the bottle under the vessel, and turning the mouth upwards, water will enter and azote will rise into the receiver. The quantity of sulphate of iron and lime here directed, is just double what would be required by calculation; but the process is thus hastened.

If a burning body be immersed in a jar of azote, it is extinguished as instantaneously as if plunged into water. No animal that breathes can live in azote; and from this circumstance is derived its name, which signifies life-depriver. It is not combustible: it enters extensively into combination: it is an abundant element in animal matter; and its existence in such large quantity, is a chief distinction between the constitution of animal and vegetable matter. There is great difference of opinion as to whether oxygen and azote are merely mixed together in the atmosphere, or whether they are in a state of chemical combination. Strong arguments have been advanced on both sides, and the question remains yet undecided. It is now no longer confined to the atmosphere, but has extended to the constitution of all mixed gases.

Those who support the opinion that the two gases are chemically combined in the atmosphere, found their belief upon facts like the following:—The specific gravity of azote is less than that of the atmosphere; the specific gravity of oxygen is greater. Now, since a certain volume of oxygen is heavier than an equal volume of azote, we should expect, that if, in the atmosphere, they be merely mixed without the operation of affinity, the oxygen would at length subside to the earth; while the azote will float above it. But we know that the fact is otherwise; for air taken from the greatest elevations to which balloons ascend, affords the same relative quantities of the two gases. Atmospheric air is also of the same composition in all parts of the world. This consideration appears to favour the opinion, that between the two cases some chemical attraction subsists: but there are also considerable objections to this view of the subject.

It may be objected, that if the oxygen and azote are thus combined, some of those chemical changes ought to be observable, which indicate combination, and new properties should be evolved. But none such are discoverable; for the specific gravity of common air is the mean of the specific gravities of oxygen and azote: and its chief properties seem to be a mean of the properties of its component gases.

A view of the subject has been proposed by Dr. Dalton, which is not liable to these difficulties, although not free from objections of another kind. Dr. Dalton conceives that the repulsion which produces the elasticity of the atmosphere, does not subsist between azote and oxygen, but between azote and azote, and between oxygen and oxygen. He conceives that, with regard to oxygen, azote offers scarcely any resistance to the indefinite expansion of that gas; and that oxygen does not resist the indefinite expansion of azote. In fact, he supposes that each acts as a vacuum to the other, and that whatever pressure a particle of oxygen at the earth's surface sustains, that pressure arises solely from all the particles of oxygen above and around it, but none whatever from those of the azote; and, conversely, that a particle of azote at the earth's surface, is pressed by all the other particles of azote in the atmosphere, but not at all by the oxygen. Each gas thus sustaining only its own weight, it would expand itself, regardless of the other; both would press upon other bodies, but neither would subside according to its weight. And although, at very great heights, there might be a difference of the relative proportions of the oxygen and azote, in consequence of the great predominance of azote in the atmosphere, this could not be observed at such heights as are within our reach. He conceives that the two gases are not in any manner chemically combined.

The most obvious objection to the hypothesis of Dalton is, that were it admitted, it should follow, that by connecting a glass globe filled with oxygen, and one filled with azote, by a stop-cock, the heavier gas being underneath, the moment the communication is opened, there should be an instantaneous mixture. Dr. Dalton made the following experiment: A pint vial filled with carbonic acid, and an ounce vial of common air, were connected by a glass tube, thirty inches long and one-third of an inch bore, so that both vials were air-tight with regard to the external air, and communicated with each other through the tube. This apparatus stood vertically, the common air vial being uppermost. In one hour, the common air vial had acquired no sensible quantity of carbonic acid gas; but in three hours it had it in great plenty. Dr. Dalton adduces this experiment, to prove that the ascent of the air in the lower vessel is not attributable to chemical affinity, as none subsists between the two gases; and he infers that it favours his hypothesis. It seems to be as much an evidence against his hypothesis as for it. If each gas acted as a vacuum to the other, there ought to be an instantaneous commixture. But, to remove this obstacle, he says, that the gases meet with some mechanical obstruction, owing to their minute division, while passing each other in contrary directions. Is it conceivable, observes Mr. Donovan, that such an obstruction could exist to the transmission of two gases through a tube one-third of an inch diameter; and that, for the space of an hour, there should not have passed even the smallest quantity of the carbonic acid gas into a vacuum? This experiment seems quite fatal to the hypothesis. He has adduced other experiments, made with the same kind of apparatus, but using gases which are not known to have any direct affinity for each other; such as carbonic acid gas and hydrogen. In the mixture which took place of these two gases with each other, Dr. Dalton conceives that affinity cannot be supposed to be concerned, as they are not known to have any affinity. That conclusion may, however, be questioned. It may be very true that carbonic acid and hydrogen do not manifest any affinity for each other in their gaseous state; but it is quite certain, that the three elements concerned—carbon, oxygen, and hydrogen—have, collectively, a powerful affinity for each other, and constitute the bases of vegetable organized matter. The obstacle to the successful exertion of their affinity, is the elastic form: but a partially successful exertion may be conceived to operate so far, that the solid elements would be retained at the limits between the calorific repulsion and chemical attraction; the latter force being active in a slight degree, but not sufficiently so to effect a combination. See Nitrogen.

Azoth, in *Alchemy;* the mercurius philosophorum, or universal remedy.

Azure, in *Heraldry,* denotes the blues in the arms of any person below the rank of baron. In engraving, this colour is represented by regular horizontal lines.

Azure, in *Painting;* a light or sky-coloured blue. This word is presumed to be derived from the Arabic lazul, which has the same meaning. The fine sky colour of lapis lazuli, and the pigment made from it, called ultra-marine, are of the greatest use to painters, both in oil and water colours. It is the most costly colour which painters employ.

Azyges, in *Anatomy;* another name for the os sphenoides.

Azygos, the name of a vein situated within the thorax, on the right side, having no similar vein on the left.

Azzalum, in *Metallurgy;* a peculiar species of iron brought from China.

BAAT; a coin current in Siam, weighing about half an ounce, and is identical with the tical of the Chinese. It is also used as a weight for other bodies.

Babylonia Cura; a term used by the astrologers to signify the art of casting nativities.

Babylonian; an epithet applied to any thing belonging to astrology.

Babylonica, in *Antiquity;* a species of rich weaving, so called from the city of Balylon, where the art of weaving hangings with a variety of colours was first invented.

Bac; a kind of praam or ferry-boat.

Bacca Bermudensis, in the *Materia Medica;* the fruit of arbor sapronaria or soap-berry tree, the kernel of which, steeped in water, raises a froth, like soap.

Baccharach Wine; a wine very much resembling Rhenish; but Portzius says that it differs from it in several particulars.

Baccharis is a sweet-scented medicinal plant, growing mostly in rough and dry grounds. The roots smell like cinnamon, and are a powerful stimulant; the leaves are moderately astringent.

Bacilli are made by mixing medicine with a proper quantity of sugar, and the mucilage of gum tragacanth; and when formed into a stiff paste, it is cut into proper portions and dried. This form is adapted for medicine designed to be slowly swallowed, as demulcents.

Bacillum; a peculiar form of medicine.

Bacillum; iron instruments used in chemistry in the shape of a staff.

Back-board; a board placed in the after part of a ship to lean against, as the back of a chair. This name is also applied to an instrument for remedying distorted spine.

Back-frame-wheel; an instrument for laying cordage.

Backing *of a wall;* the building which forms the inner face of a wall, or the act of building the inner face.

Back-painting; the method of painting mezzotinto prints pasted on glass, with oil colours. See Painting.

Back *an anchor;* to carry out a small anchor to support the larger one.

Back *astern;* to manage the oars in rowing in a direction contrary to the usual method.

Back *the sails;* to arrange them for the ship to retreat or move astern, in consequence of the tide favouring her.

Backgammon; a game played with dice, by two persons, on a table divided into two parts, upon which there are 24 black and white spaces, called *points*. Each player has 15 men, black and white, to distinguish them. The word is of Welsh origin, signifying *little battle*. The following are in brief the laws of the game: 1. If a man is taken from any point, it must be played. 2. A man is not played, till it is placed upon a point and quitted. 3. If a player has only 14 men in play, there is no penalty attending it. 4. If he bears any number of men before he has entered a man taken up, and which, of course, he was obliged to enter, such men, so borne, must be entered again in the adversary's table, as well as the man taken up. 5. If he has mistaken his throw, and played it, and his adversary has thrown, it is not in the choice of either of the players to alter it, unless both parties agree to it.

Back-piece; a portion of defensive armour strapped to the back.

Back-staff; an instrument for taking the sun's altitude, so called because the back of the observer is directed towards the sun. It consists of two concentric arcs and three vanes: the arc of the longest radius is 30 degrees, and that of the shorter 60 degrees, making altogether 90 degrees, or a quadrant of the heavens.

Back-stays; a portion of the rigging of a ship.

Back-sword; a sword with one sharp edge, employed in contradistinction to a cut-and-thrust weapon.

Bacon. This species of animal flesh is employed to so large an extent as an article of food in this country, that it may be adviseable to go somewhat into detail in the processes for preparing it. When a hog is killed for bacon, the sides are laid in large wooden troughs, and sprinkled all over with bay salt: thus they are left for twenty-four hours, to drain away the blood and the superfluous juices. After this first preparation, they should be taken out, wiped very dry, and the drainings thrown away. Next, some fresh bay salt, well heated in a large iron frying-pan, is to be rubbed over the meat, until it has absorbed the moisture, and this friction repeated four successive days, while the meat is turned only every other day. If large hogs are killed, the flitches should be kept in brine for three weeks, and, during that period, turned ten times, then taken out, and thoroughly dried in the usual manner; for, unless they be thus managed, it is impossible to preserve them in a sweet state, nor will their flavour be equal to those properly cured.

Smoked bacon, one of the most relished, but indigestible, dishes of the Germans, is prepared in a similar manner to that adopted in the curing of the celebrated Westphalia hams. For the latter, however, animals which have been well fed, and allowed to roam at pleasure in the extensive moorlands of that province, are generally selected. The manner of obtaining them is nearly as follows: after the hams have been properly salted, rubbed, and wiped with dry cloths, in order to absorb all the impure juices, the cavities of the joints, as well as the bones themselves, are carefully covered with a mixture consisting of two parts of the best salt, perfectly dried, and one part of black pepper, coarsely powdered. As soon as this operation is performed, the hams are, on the same day, suspended in a chimney, where no other but wood fire is burnt, and which is usually increased during the first three days. The time of fumigation is regulated by the size of the meat, and generally extends from three to six months.

Bacon, *Fossil*. See Adipocire, for which it is but a vulgar name.

Bacule, in *Ancient Fortification;* a species of lever-trap to destroy those entering the portcullis.

Bacudometry; a mode of measuring distances.

Badiaga; a species of spongy plant; the powder of which is said to act very rapidly on livid tumours.

Badigeon; a mixture employed both by statuaries and carpenters to hide defects in their work.

Bag, in *Commerce;* a determinate quantity of goods contained in a bag, varying in size according to the article or the place, from three to four hundred weight.

Bag, in *Pharmacy;* various ingredients applied externaly, so as to act by the absorbents.

Bag, in *Farriery;* attached to the bridle-bit. It contains savin and assafœtida.

Baggage; part of the equipment of an army.

Bagnette, in *Architecture;* a small round moulding, generally enriched with laurel leaves and ribbons.

Bagnette Divinatore, see Divining Rod.

Bagpipe; a well-known wind instrument, of high antiquity among the northern nations, which has so long been a favourite with the natives of Scotland, that it may be considered as their national instrument. It consists of two principal parts: the first comprises a leather bag, which receives and holds the wind conveyed to it by a small tube, furnished with a valve, to prevent the wind from returning. The second part of the instrument consists of three pipes,—the great pipe or drone; a smaller pipe, which emits the wind at the bottom; and a third with a reed, through which it is blown. The wind is forced into the pipes by compressing the bag under the arm, while the notes are regulated, as in a flute or hautboy, by stopping and opening the holes, which are eight in number, with the ends of the fingers. It is not known when the bagpipe first found its way into

Scotland, but it is probable that the Norwegians and Danes first introduced it into the Hebrides, which islands they long possessed. Aristides Quintilianus informs us, that it prevailed in the Highlands in very early ages; and indeed the genius of the people seems to render the opinion highly probable. The attachment of that people to their music, called pibrachs, is almost incredible, and on some occasions is said to have produced effects little less marvellous than those ascribed to the ancient music. At the battle of Quebec, in 1760, while the British troops were retreating in great disorder, the general complained to a field-officer in Fraser's regiment of the bad behaviour of his corps. "Sir," said he, with some warmth, "you did very wrong, in forbidding the pipers to play this morning; nothing encourages the Highlanders so much in the day of action. Nay, even now they would be of use."—"Let them blow like the devil, then," replies the general, "if it will bring back the men." The pipers were then ordered to play a favourite martial air; and the Highlanders, the moment they heard the music, returned and formed with alacrity in the van. In a former war in India, Sir Eyre Coote, aware of the attachment of the Higlanders to their favourite instrument, gave them fifty pounds to buy a pair of bagpipes after the battle of Porto Nuovo. In Rome, at the time of Advent, the peasants of the mountains play on the bagpipe before the images of the Virgin. The music is very simple, and yet sweet; and every traveller remembers it with delight.

Bag-reef; the lowest reef in a sail.

Bail; to empty of water.

Bailbone; an heradic charge, representing a lion rampant holding a staff in his mouth.

Bails; the frames which support the awning or tilt of a boat.

Baiocco; a small coin in the Roman states, a hundred of which make a Roman crown.

Baize, in *Commerce*; a kind of coarse, open, woollen stuff, having a long nap; sometimes frized on one side, at other times not frized, according to the uses for which it is intended.

This stuff is without wale, being manufactured on a loom with two treddles like flannel. It is chiefly manufactured about Colchester and Bocking, in Essex; and in Flanders, about Lisle and Tournay, &c. This manufacture was first brought into England, together with that of says, serges, &c., by the Flemings, who fled hither from the persecution of the Duke of Alva, about the fifth year of the reign of Queen Elizabeth, and had afterwards peculiar privileges granted them by the 12 Car. II. in 1660. The exportation of baize was formerly much more considerable than it is now, as the French manufacturers have learned to imitate them, and have set up manufactures of their own at Nismes, Montpellier, &c. However, a considerable quantity of baize is still exported to Spain, Portugal, and Italy. Their chief use is for the religious, and for linings in the army; the looking-glass makers also use them behind their glasses, to preserve the tin or quicksilver; and the case-makers to line their cases.

The breadth of baize is commonly a yard and half, yard and three-quarters, or two yards; by forty-two or forty-eight in length: those of a yard and three-quarters are most proper for the Spanish trade.

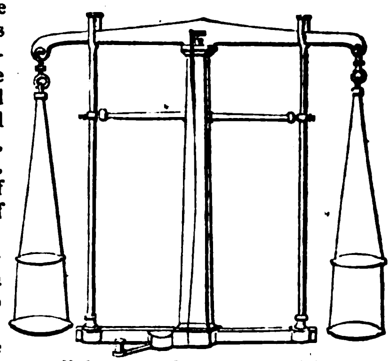
Baking is the art of converting flour, or other farinaceous substances, into bread. A proper degree of heat is an essential requisite to the baking process. When the inner arch of the oven appears entirely white, it is generally considered as sufficiently heated. But this being a fallacious criterion, the following arrangement has been recommended:—Place a handful of flour close to the aperture of the oven, and if it turn of a brown colour, the heat is then nearly of the degree required; but if it become black, or remain white, in the former case the fire must be considerably reduced; and in the latter, more fuel must be added. See Bread.

Balalaika, in *Music*, a musical instrument of the bandour kind, of very ancient Sclavonian origin; it is in common use both with the Russians and Tartars; according to the celebrated Niebuhr, it is also frequent in Egypt and Arabia. The body of it is an oblong semi-circle, about six inches in length, with a neck or finger-board of two feet. It is played on with the fingers like the bandour or guitar; but has only two wires, one of which gives a monotonous bass, and by the other the piece is produced.

Balance. This important instrument may be considered as consisting of an inflexible rod or lever, called the beam, furnished with three axes; one, the fulcrum or centre of motion, situated in the middle, upon which the beam turns, and the other two near the extremities, and at equal distances from the middle. These last are called the points of support, and serve to sustain the pans or scales. The points of support and the fulcrum should be in the same right line. The arms of the lever being equal, it follows, that if equal weights be put into the scales, no effect will be produced on the position of the balance, and the beam will remain horizontal.

If a small addition be made to the weight in one of the scales, the horizontality of the beam will be disturbed; and after oscillating for some time, it will, on attaining a state of rest, form an angle with the horizon, the extent of which is a measure of the delicacy or sensibility of the balance.

What we have now stated, will serve to illustrate the principle of the balance. Its mode of construction will be best understood by a diagram.



One of the best form is here represented. The parts are all so arranged that it can, at pleasure, be lifted off the points of support.—This is effected by aid of the two uprights, which are elevated by a small lever at the bottom. The scale pans are made of glass or platina. If the former be employed, care should be taken to prevent their being excited electrically, which would materially affect the results. This is particularly alluded to, as the Editor has seen a difference of more than half a grain produced, by merely cleaning one of the glass scale pans with a dry silk handkerchief.

In order to have a balance as perfect as possible, it is necessary to attend to the following axioms:

1. The arms of the beam ought to be exactly equal both as to weight and length.

2. The points from which the scales are suspended, should be in a right line, passing through the centre of gravity of the beam; for by this, the weights will act directly against each other, and no part of either will be lost, on account of any oblique direction.

3. If the fulcrum, or point upon which the beam turns, be placed in the centre of gravity of the beam, and if the fulcrum and the points of suspension be in the same right line, the balance will have no tendency to one position more than another, but will rest in any position it may be placed in, whether the scales be on or off, empty or loaded.

If the centre of gravity of the beam when level, be immediately above the fulcrum, it will overset by the smallest action; that is, the end which is lowest, will descend; and it will do this with more swiftness, the higher the centre of gravity be, and the less the points of suspension be loaded.

But if the centre of gravity of the beam be immediately below the fulcrum, the beam will not rest in any position but when level; and if disturbed from that position, and then left at liberty, it will vibrate, and at last come to rest on the level. In a balance, therefore, the fulcrum ought always to be placed a little above the centre of gravity. Its vibrations will be quicker, and its horizontal tendency stronger, the lower the centre of gravity, and the less the weight upon the points of suspension.

4. The friction of the beam upon the axis ought to be as little as possible; because, should the friction be great, it will require a considerable force to overcome it; upon which account, though one weight should a little exceed the other, it will not preponderate, the excess not being sufficient to overcome the friction, and bear down the beam. The axis of motion should be formed with an edge like a knife, and made very hard: these edges are at first made sharp, and then rounded with a fine hone, or piece of buff leather, which causes a sufficient bluntness, or rolling edge. On the regular form and excellence of the axes, depends chiefly the perfection of this instrument.

5. The pivots, which form the axis or fulcrum, should be in a straight line, and at right angles to the beam.

6. The arms should be as long as possible, relatively to their thickness, and the purposes for which they are intended; as the longer they are, the more sensible is the balance.

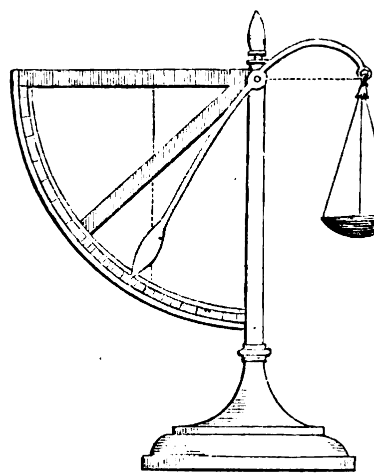
They should also be made as stiff and inflexible as possible; for if the beam be too weak, it will bend and become untrue.

7. The rings, or the piece on which the axis bears should be hard and well polished, parallel to each other, and of an oval form, that the axis may always keep its proper bearing, or remain always at the lowest point.

8. If the arms of the balance be unequal, the weights in equipoise will be unequal in the same proportion. The equality of the arms is of use in scientific pursuits, especially in the making of weights by dissection. A balance with unequal arms will weigh as accurately as another of the same workmanship with equal arms, provided the standard weight be first counterpoised, then taken out of the scale, and the thing to be weighed be put into the scale, and adjusted against the counterpoise. Or when proportional quantities only are considered, the bodies under examination may be weighed against the weights, taking care always to put the weights in the same scale; for then, though the bodies may not be really equal to the weights, yet their proportions amongst each other will be the same as if they had been accurately so.

In order to try the goodness of a pair of scales, the scales should be taken off the beam to ascertain if the beam balances without them; they should then be put on again and afterwards reversed, or each scale hung on the opposite end of the beam which it before occupied. Equal weights should then be put into the opposite scales, and these should in like manner be reversed or changed; and if the beam maintains its horizontal position under all these changes, it may be relied on as being good and perfect. The pivots or fulcrum upon which the beam turns ought to be sharp, or knife edged, as it is termed, and they should be of steel well hardened, as well as the interior of the ring in which they move: this confines the fulcrum to a minute line, and prevents friction. In beams for nice purposes, the pivots ought not to be too much elevated above the centre of gravity, for although this centre will generally be found an inch or two below the pivots in strong warehouse beams, in order to bring them to a speedy equilibrum, by which time is saved; yet, for accurate weighing, the nearer the centre of gravity is brought into the straight line that would connect the tops of the two scale eyes, and the under side of the pivot, the better; although such a beam will occasion great loss of time by its vibrating a long time before it becomes stationary.

The *steelyard balance* is an imperfect modification of the instrument we have already described. It is merely a balance of which the arms are unequal, and a weight is made to slide along the longest arm, the scale-pan being fixed at the other extremity. Now it will be obvious, by the slightest reference to the principle of this arrangement, that the expansion of the longest arm will alone render the instrument to a certain extent defective.



The *bent lever balance*, shown above, is somewhat similar in its operation to the steelyard. It acts by a fixed weight, increasing in power as it ascends along the arc of a circle, and the scale on the graduated qaudrant indicates the amount of weight.

With this instrument, one constant weight serves to weigh all others in the range of the balance, by only varying the position of the arms of the instrument, instead of varying the places or points of suspension in the arms themselves.

Mr. Patten, of Newport, in the United States, has invented a very ingenious balance for taking specific gravities. It is thus described in Siliman's *Journal:*

"One great objection to the usual balance, is the difficulty of getting the points of suspension of the scales to be at equal distances from the point of suspension of the beam; another is the friction—this alone is sufficient to prevent the substance to be weighed from containing an exact quantity of matter with the weight used; for suppose a beam to be so nicely constructed as to turn with the tenth of a grain—now to weigh 100 grains, that weight will be put into one dish, and the substance into the other, but a tenth of a grain must be added before the scale can turn perceptibly; it therefore exceeds 100 grains by the tenth of a grain, and the weights can only be equivalents when the index is at rest, which may be any where within the quantity required to turn the beam—sufficiently accurate for all common purposes, but not for weighing the gases and taking accurately specific gravities; and in analysis, where the weights are often repeated, its amount is considerable. The only accurate method is to make the weight itself the standard. To do this is the object of the beam made of steel, sufficiently strong and light. The dish is suspended, the beam itself upon an axis, the milled head of a long screw that is fitted with a shoulder and axis, and goes through the slide that traverses and carries the weight. Now, suppose it is wished to obtain ten grains; place that weight in the dish, and screw back the weight until it exactly counterbalances it. If the weight be now removed, and a quantity of the substance to be weighed is substituted until the index points to where it did at first, there will then be very nearly the exact weight, with but a small allowance for friction; for were this beam a common one, and so nicely constructed as to turn with the 100th part of a grain, it would make the distance four times greater from the point of suspension of the weight, turn with the 400th part of a grain. It is apparently an objection that 100 grains will require 400; but the fact is settled by Coulomb, that this kind of friction does not increase in an equal proportion with the weights used; that is, if with a pound in each scale, a beam turn with one grain, if there were two pounds in each, it would require two grains.

"The beam may be used as a steelyard, by screwing the weight to any number marked upon the scale; and should a greater quantity be required, then another of double the weight may be substituted."

The usefulness of having good balances for the weighing of substances, is not limited to the due performance of nice experiments, but they also save much time in weighing, when a less degree of accuracy is required. If a pair of scales, loaded with a certain weight, be barely sensible to one-tenth of a grain, it will require a considerable time to ascertain the weight to that degree of accuracy, because the turn must be observed several times over, and is very small; but if scales were used which would turn with the hundredth part of a grain or less, supposing that the weight was not required to any greater accuracy than the tenths of grains, a single tenth of a grain, more or less, would make so great a difference in the turn of the scale, that it would be seen immediately.

For the determination of the specific gravity of various substances, Muschenbrock says, he used a balance which turned within a fortieth of a grain when loaded with 200 or 300 grains; hence his balance determined the weight to the 12,000th part of the weight.

Mr. Bolton's larger balance (mentioned in *Phil. Trans.*, vol. 66), loaded with a pound, probably of the common avoirdupois, would turn with one-tenth of the grain; so that the weight is determined to the 70,000th part of the entire mass.

Mr. Bolton's small balance, capable of weighing half an ounce, turned with the hundredth part of a grain; which is the 24,000th part of the weight.

Mr. Reid's balance, mentioned in the same volume, when loaded with 55lbs. avoirdupois, turned readily with less than pennyweight, and a very distinctly with four grains, so that it determined the weight to the 96,000th part of the weight in the scale; and although so strong, is decidedly the best common balance whose performance has been recorded.

Mr. Whitehurst's balance, mentioned in the same volume, which weighed one pennyweight, was sensibly affected with the 2,000th part of a grain, or the 48,000th part of the weight.

Mr. Nicholson's balance, noticed by him in his *Dictionary of Chemistry*, when loaded with 12,000 grains in each scale, turned with the 70th part of a grain or the 84,000th part of the weight; so that this was a very good balance.

Mr. Alchorne's balance (mentioned in the *Phil. Trans.*, vol. 77), with 15lbs. at each end, turned with two grains; they were probably Troy pounds, and so the accuracy of this balance went only to the 43,200th of the weight.

Dr. G. Fordyce (in the *Phil. Trans.*, vol. 75) mentions a balance, made by Ramsden, turning on points instead of edges, which when loaded with four or five ounces Troy, could ascertain the weight to the 160th part of a grain; that is to say, the 30,400th part of the weight in the scale.

Mr. Maggellan's balance, mentioned by Nicholson in his *Dictionary of Chemistry*, with a pound in each scale, showed distinctly one-tenth of a grain, or the 70,000 part of the weight.

The Royal Society's balance, made by Ramsden, and turning on steel edges upon planes of polished crystal, is said to be sensible to the 7,000,000th part of the weight.

The comparison of the weights of different countries, as made by Mr. Tillet, with the standard mark in the mint at Paris, was made with a balance which weighed a coin of 4,608 grains, and turned with a quarter of a grain, or the 18,432d part of the weight in the scale; so that although this balance might be reckoned a good one, it was in fact inferior in accuracy to any of the above-mentioned, except Muschenbrock's.

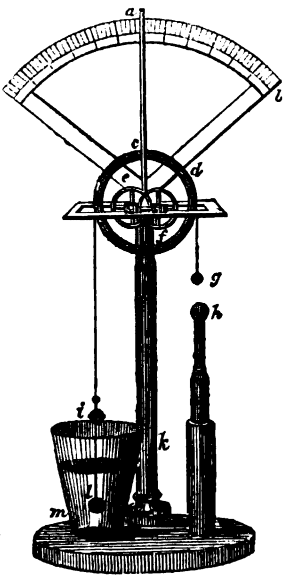
Professor Weigel, in his *Observations*, says, he used a balance which, when loaded with two marks, Cologne weight, at each end, the beam turned 1-12th of an inch with a foreign coin, which, according to the German weights, given in Mr. Gray's *Elements of Pharmacy*, is the 131,072d part of the weight in each scale; so that this balance was a very good instrument.

The balance used by Mr. Cooper (*Trans. Soc. Arts*, vol. 41), and made by Mr. Robinson, was sensibly affected by 1-400th of a grain, when the scales were loaded with 1000 grains at each end; so that this balance may be esteemed of very great accuracy, and very fit for the purposes to which it was applied; namely, the analysis of organic substances by fire.

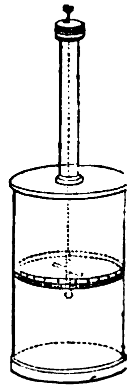
In all researches which depend upon the accurate weighing of the articles employed, and of the products obtained, the accuracy of the balance employed ought ever to be stated, in order that it may be determined what confidence ought to be placed in the results obtained.

The mechanic will, from this account of balances, be able to form a proper estimate of the value to be attached to tables of specific gravity, or to chemical analysis, which depend on a supposed accuracy in weighing which is not attainable in practice. When, indeed, tables of specific gravity are given to five places of figures, the last figure is merely a guess figure; and if they have more than five figures, the author, as Nicholson justly observes, either deceives intentionally, or through ignorance of decimals.

Balance, Electrical; an instrument employed to measure the repulsive and attractive powers of electrified bodies. The nature and operation of this apparatus will be best understood by reference to the accompanying illustration.

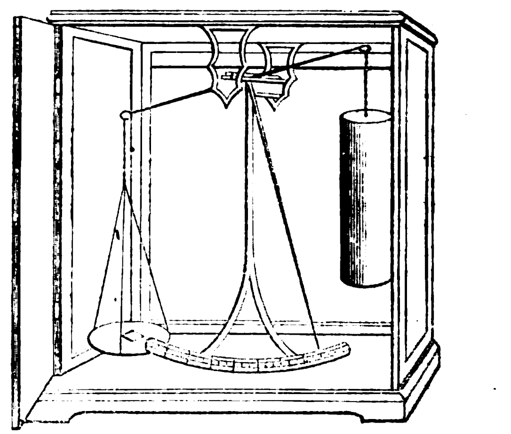


It consists of a large graduated arc, *d*, supported by a projecting plate of brass which is attached to the perpendicular column *k*, the axle of this wheel rests on four small friction wheels, *ff*, and its centre is that of the graduated arc *ab*. Attached to the axle is an index, *c*, formed of an exceedingly fine straw, the motion of which in connection with that of the wheel *d* serves to indicate the amount of revolution of the latter. Over this wheel, and in a groove, at its circumference, passes a line, to the one extremity of which is attached a light ball of gilt wood, *g*, and to the other, a float *il*, which consists of a glass tube about two-tenths of an inch in diameter, terminating in a small bulb, *l*, at its lower end, which contains a small portion of mercury or some very fine shot, put into it for the purpose of adjusting the instrument, so that the index hand, *c*, may point to the *zero* division, or that in the centre of the arc, as exhibited in the engraving. The difference of the weight of this float when in and out of the water is known, and every tenth of an inch of the tube which is immersed or emerged, according as it sinks or rises on the fluid, is made to correspond, by employing a wheel of its required circumference with five divisions of the arc. The body, whose electricity is to be measured, is presented at *h*, and its attractive or repulsive power relative to the ball *g* is estimated by the rising or falling of the float in the fluid, and the consequent motion of the index hand, *c*, over a corresponding portion of the arc *a*. When the attractive force of the two bodies is to be estimated, the line, which passes over the wheel *d* must be formed of two parts, the lower part being of silver thread and the remainder of silk; when their repulsive force is to be estimated, the whole is of silk.



Balance Torsion. This instrument was first suggested by Coulomb, for electrical purposes: it is, however, equally fitted for measuring the intensity of the magnetic force. It consists of a glass cylinder, on which is placed a plate supporting an upright tube. In the centre of the tube is a brass circle and hook, supporting a fine silk thread. Now, we may suppose a small magnet suspended by the line, and all communication with the air cut off by the glass case. On bringing a magnet, whose strength we wish to measure, in contact with the glass, the experimenter will find, by the point of graduation at which it acts on the suspended needle, the exact power of the secondary magnet.

Balance *for the Weather*. This is an instrument which serves to indicate the density of the air, and,



as such, the chances of rain or dry weather. The balance in the above figure has its arms equal, and to one side is attached a large and thin cylinder, exactly balanced by a brass weight in the scale. Now, if we suppose the beam to be in equilibrio when the air is at a given density, and the air become heavier, the equilibrium will be destroyed, as the large cylinder displaces more air than the brass weight, and as such will be more buoyant, and ascend. If, on the contrary, the air become lighter, then it will sink. A rod descending from the scale beam, by passing over the graduated arch, serves to indicate the weight of the air at the time of making the observation. If the air be heavy, then fine weather may be expected; but if the cylinder sink, then rain is the usual result.

Balance, in *Horology*. See Watch-Making.

Balancing; among seamen, the contracting a

sail into a narrower compass, in a storm, by folding up a part of it at one corner, by which it is distinguished from *reefing*. Balancing is peculiar to few sails.

BALCONY, in *Architecture;* a projection from the front of a house, surrounded by a balustrade or open gallery. In common houses these are simple projections, supported by trusses of wood, stone, or iron, and surrounded by a plain or ornamental railing; but they are susceptible of considerable elegance of decoration, and may be supported by columns, caryatides, carved trusses, or cantalivers, and covered by elegant canopies, supported in a similar manner.

BALDACHIN, in *Architecture* and *Sculpture;* a kind of canopy, ornamented with sculpture, and supported by columns for the embellishment of altars; but more particularly used to those which are insulated, like the great altar in the church of St. Peter at Rome.

BALDWIN'S PHOSPHORUS, a phosphorescent substance, formed by calcining nitrate of lime at a low red heat.

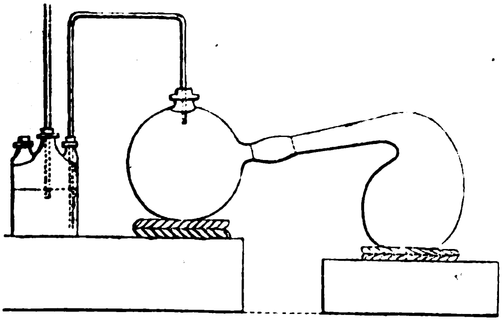
BALISTÆ or BALLISTÆ; a kind of machine for besieging, or attacking the besiegers, in use among the ancients, by which heavy stones, also arrows and other weapons, were thrown; and even burning substances and dead bodies, by the besiegers. Many of the ancient writers confound the *balistæ* with the *catapultæ*, but Polybius makes a difference, using the latter word only for those machines which threw stones. The mechanism of these machines is not quite clear. There is a third name for a kind of these machines—*onager*. The weight of the stones thrown was from 10 to 300 pounds. Sometimes a large quantity of stones was thrown at once. A clear idea of these instruments cannot be formed without the study of treatises on the arms and warfare of the ancients. See ARIES.

BALK, in *Agriculture;* a ridge or bank between two furrows, or pieces of arable land.

BALLIUM, in *Ancient Architecture;* the court within a fortified castle. There were generally two, the outer ballium immediately within the gates, separated by a wall from the inner ballium, which contained the apartments for the garrison and governor. St. Peter in the Bailey, at Oxford, stands in the outer ballium of the castle. The Old Bailey in London is so named for occupying a similar situation.

BALLOON. See AERONAUTICS.

BALLOON, in *Chemistry*. This is a very useful glass implement. Its application is shown in the



wood-cut, in which a retort is seen entering the mouth of the balloon to which it is luted. In this case it serves to condense the vapour which passes from the retort, and thus forms a distillatory apparatus. The non-condensible gases pass up by the bent tube, and then descend beneath the level of the water in a Woulfe's bottle.

BALLAST (from the Danish *baglast*), is a load of sand or stones, deposited in ships, which have not freight enough to sink them to their proper depth in the water, so as to resist the wind and waves. In storms, if the vessel leaks, part of the ballast must often be thrown out, to make the vessel lighter. By the English navigation act, and by the laws of other commercial nations, subsequently established, vessels are often obliged to take ballast, either on their departure or return, instead of transporting, even at little profit, heavy and cheap goods of the country, to foreign states.

Mr. Rewcastle has an ingenious patent mode of preserving the equilibrium of ships, which may here be noticed. The intention of the patentee is to ballast vessels by means of water introduced into the hold of the ship, instead of dry articles. In order to effect this object, he proposes to divide the hold of the vessel into a number of distinct compartments, by placing partitions between the ribs or timbers, which are to be made up by boarding, and the joints carefully caulked, so as to prevent the leakage of water; over the planking, is to be placed sheets of felt, such as are usually prepared for sheathing the bottoms of ships, and upon these may be placed sheets or plates of iron, which being made perfectly tight, will constitute a series of tanks capable of holding water, by which the ship is to be ballasted.

In such ships as are weak in their structure, it may not be desirable to form the compartments or tanks as parts of the vessel itself, it is therefore proposed, in those instances, to construct moveable tanks or boxes of iron, which shall exactly fit those parts of the hold where the ballast is to be placed; and these tanks being filled with water, will answer the same purpose.

The tanks, whether made as compartments in the hold of the ship, or as distinct tanks to be placed in the hold, must be securely covered to prevent the water from flowing over, as the ship rolls or pitches, and pipes must be properly placed, leading to the tanks, for the purpose of conducting the water into these, and other pipes, to discharge it, which pipes must be furnished with stop-cocks; and there must also be tubes in the tops of the tanks, to allow of the ingress and egress of the air.

BALM OF GILEAD is the dried juice of a small tree or shrub (*amyris gileadensis*), which grows in several parts of Abyssinia and Syria. This tree has spreading, crooked branches; small, bright-green leaves, growing in threes; and small, white flowers on separate footstalks. The petals are four in number, and the fruit is a small, egg-shaped berry, containing a smooth nut.—By the inhabitants of Syria and Egypt, this balsam, as appears from the Scriptures, was in great esteem from the highest periods of antiquity. We are informed by Josephus, the Jewish historian, that the balsam of Gilead was one of the trees which was given by the queen of Sheba to king Solomon. The Ishmaelitish merchants, who were the purchasers of Joseph, are said to have been travelling from Gilead, on the eastern side of Canaan, to Egypt, and to have had their camels laden with "spicery, balm and myrrh." It was then, and is

still, considered one of the most valuable medicines that the inhabitants of those countries possess. The virtues, however, which have been ascribed to it exceed all rational bounds of credibility. The mode in which it is obtained is described by Mr. Bruce: The bark of the tree is cut with an axe, at a time when its juices are in their strongest circulation. These, as they ooze through the wound, are received into small earthern bottles; and every day's produce is gathered, and poured into a larger bottle, which is closely corked. When the juice first issues from the wound, it is of a light-yellow colour, and a somewhat turbid appearance; but, as it settles, it becomes clear, has the colour of honey, and appears more fixed and heavy than at first. Its smell, when fresh, is exquisitely fragrant, strongly pungent, not much unlike that of volatile salts; but if the bottle be left uncorked, it soon loses this quality. Its taste is bitter, acrid, aromatic, and astringent. The quantity of balsam yielded by one tree never exceeds 60 drops in a day. Hence its scarcity is such, that the genuine balsam is seldom exported as an article of commerce. Even at Constantinople, the centre of trade for those countries, it cannot, without great difficulty, be procured. In Turkey, it is in high esteem as a medicine, an odoriferous unguent and cosmetic. But its stimulating properties upon the skin are such, that the face of a person unaccustomed to use it becomes red and swollen after its application, and continues so for some days. The Turks also take it in small quantities, in water, to fortify the stomach, and excite the animal faculties.

Balsam. The term *balsam* was formerly applied to any strong-scented, natural, vegetable resin, of about the fluidity of treacle, inflammable, not miscible with water without addition, and supposed to be possessed of many medical virtues. All the turpentines, the Peruvian balsam, copaiba, &c., are examples of natural balsams. Many medicines, also, compounded of various resins or oils, have obtained the name of *balsams;* as Locatelli balsam, &c. Lately, the term has been restricted to those resins which contain benzoic acid. The most important balsams are those of Tolu and Peru—*storax* and *benzoin*, as they are named: the latter is concrete, the former fluid, though becoming solid with age. They are odorous and pungent, and useful only as articles of the materia medica. The benzoic acid is extracted from them by applying a gentle heat, when it is volatilized and afterwards condensed.

Baluster, in *Architecture;* a small turned column usually introduced between piers, on the upper parts of large buildings under windows, and on balconies, &c.

Balustrade, in *Architecture;* a row of balusters.

Bangue; a kind of opiate, much used throughout the East as a means of intoxication. The Persians call it *beng*. It is made of the leaf of a kind of wild hemp, in different ways.

Banner; a word found in all the modern languages of western Europe, the origin of which, however, is given in many very different ways. It signifies the colours, or standard. Among the ancient Germans, if a knight was able to lead 10 helmets, that is to say, 10 other knights, against the enemy, the duke (*herzog*) gave him a banner, and he was called a baneret (*bannerherr*). In some republics, banneret, or standard-bearer, was the title of one of the highest officers, as the *gonfalionere* of Florence and other Italian republics, and the *bannerherr* in the Swiss republics. Banneret, in England, was a knight made in the field, with the ceremony of cutting off the point of his standard, and making it a banner—a custom which has long since ceased. Several banners are famous in history, as the Danish banner, taken from the Danes by Alfred the Great, the *oriflamme*, &c. Catholic churches generally have their banners.

Banquette, in *Fortification;* the elevation of earth behind a parapet, on which the garrison of a fortress may stand, on the approach of an enemy, in order to fire upon them. The height of the parapet above the banquettee (the height of defence), is usually about four feet six inches; the breadth of the banquette, when it is occupied by one rank, two and a half to three feet; when it is occupied by two ranks, four to six feet. It is frequently made double, that is, a second is made still lower.

Barbette; an elevation of earth behind the breastwork of a fortification or intrenchment, from which the artillery may be fired over the parapet. The height of the breasting (the part of the parapet which covers the cannon) is generally 3½ feet; the length of the barbette, 14 to 16 feet; the breadth for every cannon, 16 to 18 feet. An ascent leads from the interior of the intrenchment to the barbette. When the garrison has much heavy ordnance, or the enemy has opened his trenches, or when it is determined to cannonade the intrenchments of a given point, as, for example, a bridge or pass, and the direction of the cannon is not to be materially changed, it is usual, instead of making a barbette, to cut embrasures in the parapet: on the contrary, firing from the barbette is expedient when the soldiery expects to be attacked only by infantry, or wishes to cannonade the whole surrounding country.

Barilla; the term applied, in commerce, to a product obtained from the combustion of certain marine vegetables. This word is the Spanish name of a plant (*salsola soda*), from the ashes of which is produced the above substance, which affords the alkali (soda). This is also procured from the ashes of prickly saltwort, shrubby saltwort (*salsola frutiosa*), and numerous plants of other tribes. The plants made use of for burning differ in different countries; and the residue of their incineration contains the soda in various states of purity. The barilla derived from the *abesembryanthemum nodiflorum* of Spain, and the *M. copticum* of Africa, contains from 25 to 40 per cent. of carbonate of soda; whereas that from the *salsola* and the *salicornia* of other districts affords about half this quantity; and the particular variety known under the name of *kelp*, procured by burning various sea weeds, is a still coarser article, not yielding above 2 or 3 per cent. of real soda. To obtain the carbonate of soda, it is only requisite to lixiviate the barilla in boiling water, and evaporate the solution.—On the shores of the Mediterranean, where the preparation of soda is pursued to a considerable extent, the seeds of the plants from which it is obtained are regularly sown in places near the sea. These, when at a sufficient state of maturity, are pulled up by the roots, dried, and afterwards tied in bundles to be burnt. This, in some places, is done in ovens constructed for the purpose, and, in others, in trenches dug near the sea. The ashes, whilst they are hot, are continually stirred with long poles, and the saline matter they contain forms, when cold, a solid mass, almost as

hard as stone. This is afterwards broken into pieces of convenient size for exportation. The best sort of Spanish soda is in dark-coloured masses of a bluish tinge, very heavy, sonorous, dry to the touch, and externally abounding in small cavities. Its taste is very sharp, corrosive, and strongly saline. The important uses of soda in the arts, and especially the constant consumption of it in the manufacture of all kinds of fine and hard soaps, are well known. The greater part of the barillas or crude sodas of commerce are now obtained from the ashes of various sea weeds, which manufacture is extensively prosecuted upon the extensive shores of Scotland.

A new mode of preparing barilla must now be noticed, it is the patent invention of Mr. M'Leod. We cannot do better than quote his specification, as it gives a concise view of the process, and the circumstances which led to the discovery.

"Travelling along the coast of Coromandel, at certain seasons of the year, the ground in many places is observed to be covered with a white efflorescence, which on examination will be found to consist chiefly of muriate and sesqui-carbonate of soda. These substances are collected by the natives, and used by them for a variety of purposes.

"The ground on which this efflorescence appears, is never covered with verdure. The soil is a deep sand with a mixture of clay, carbonate of lime, &c. The clay contains, as it generally does, some oxide of iron, of which whole fields on the west side of the great Pulicate Lake, forty or fifty miles north of Madras, are of this description.

"Carbonate of soda is met with only on the surface, and it is found in greatest abundance a few weeks after the periodical rains have ceased. The natives begin collecting it in March, and continue to do so during the hot weather that succeeds. The saline crust is scraped from the surface, mixed with sand and clay, washed in water so as to separate some of the insoluble matter, and the watery solution is evaporated to dryness. The residuum thus obtained, is the karum of the bazars, and is the only preparation hitherto made or used in India of these materials.

"This karum contains from four to six or eight per cent. of soda, and the rest consists of carbonic acid, sand, clay, muriate of soda, decomposed vegetable matter, and occasionally other impurities. Various attempts have been made to introduce this substance into our manufactories, and with this view consignments of it have at different times been sent from Madras, but the nature and quantity of its impurities effectually excluded it.

"Some years ago it occurred to me, that if it were divested of some of its insoluble matter, and submitted to the action of fire so as to free it from a portion of carbonic acid, decomposed vegetable matter, water, sulphur, and other volatizable impurities, it might become an article of considerable importance. I conceived that if the karum were treated in this manner, and fused in a reverberatory or other furnace, it might be converted into a substance resembling barilla, which would be found a perfect substitute for that article. This idea I soon after put in practice, but my first attempts were unsuccessful.

"The materials above mentioned being fused in a reverberatory furnace, became a mass of green glass, in consequence of their containing a quantity of silecious matter, of which they had not been sufficiently divested. It therefore became necessary to get rid of this admixture by more careful solution and evaporation to dryness, as already mentioned. These operations being performed with sufficient care, the residuum underwent the action of fire without any sensible portion being converted into glass, and the fused mass being withdrawn and cooled, resembled very fine barilla in most of its essential properties; and in fact passes current in the London and Antwerp markets as barilla of a superior quality."

Bark, Peruvian, is the produce of various species of the *cinchona*, which is the spontaneous growth of many parts of South America, but more particularly of Peru. The tree is said somewhat to resemble a cherry-tree in appearance, and bears clusters of red flowers.—This valuable medicine was formerly called *Jesuit's bark*, from having been introduced into Europe by the members of that religious order, who were settled in South America. They were instructed in the use of it by the natives of Peru, to whom it had been long known; and it continued, for many years, a source of profit to the order. Its botanical name was derived from that of the Countess del Cinchon, the lady of a Spanish viceroy, who had been cured by it. The tree from which it is obtained grows abundantly in the forests of Quito and Peru, and the bark is cut by the natives in the months of September, October, and November, during which alone, the weather is free from rain. The bark is of three kinds—the red, the yellow, and the pale. The first has now become scarce, but has also lost the exclusive reputation which it once had, the yellow and pale barks having been found to be stronger in their febrifuge properties. The *crown-bark*, as the highest priced is termed, is of a pale, yellowish-red. The uses of the bark in medicine are too well known to need description; but the chemical discoveries in relation to it are deserving of more particular mention. Its medical properties were found, a few years since, to depend upon the presence of a substance called *quinine*. This exists, more or less, in all kinds of Peruvian bark, but in quantities very unequal in the various kinds. It was discovered by Messrs. Pelletier and Cavatou, who also ascertained that the most useful and permanent form of the substance was that of a neutral salt, in which it was combined with sulphuric acid, constituting the celebrated sulphate of quinine. This extract is so powerful, that one grain of it is a dose; and thus does this little powder, which is almost imperceptible, supply the place of the nauseous mouthsful of bark, which were absolutely eaten by the unfortunate beings who were afflicted with the ague, before this invaluable article was discovered. Next to the bleaching liquor and the gas-lights, this may be regarded as the most valuable of the gifts of chemistry to her sister arts. So extensive has the manufacture of this most important article become, that, in 1826, no less than 1593 cwt. of bark were used by four chemists concerned in the production of it in Paris; and 90,000 ounces of sulphate of quinine were produced in France in the same year, being enough for the curing, at a fair calculation, of near 2,000,000 of sick, who have by this most happy discovery, been spared the swallowing of at least 10,000,000 ounces of crude bark. This one discovery should entitle the name of Pelletier to the gratitude of all posterity. It may be added as a curious fact in pharmaceutical chemistry,

that the same genius which enabled our Gallic neighbours to extract this important principle from a coarse and woody fibre, has not yet taught them the most convenient mode of preparing it as a medicine. On the Continent it is usually taken in the form of a powder, and the Editor of this work, on asking for the sulphate of quinine prepared as pills, has repeatedly been recommended to take the white and bitter powder between bread and butter. In this country it is usually taken in the form of a pill, or in the infusion of rose leaves.

Barometer. There is no philosophical instrument so much consulted as the one we are now about to describe. Strictly speaking, it can rarely be considered as a perfect index to the ever-varying density of our atmosphere, but there is no other contrivance which science has furnished equally calculated for foretelling changes in the weather. It would be a waste of our reader's time to go much into the history of the barometer, and it may be enough to state that Torricelli discovered the principle on which it acts, but Pascal applied that principle to useful purposes in the construction of what is properly called the weather-glass.

It has been shown in the articles Air and Atmosphere, that the invisible fluid which surrounds us, is material,—possesses weight, and as such, must press on all bodies which are immersed in it. Now, if by a very simple process, which will shortly be described, we remove the weight of the air from within a tube, and fill the tube with mercury, the fluid will remain suspended, and in a state of equilibrium, when the column of mercury is an exact balance to the air's pressure. Now this is exactly the arrangement adopted in constructing the barometer.

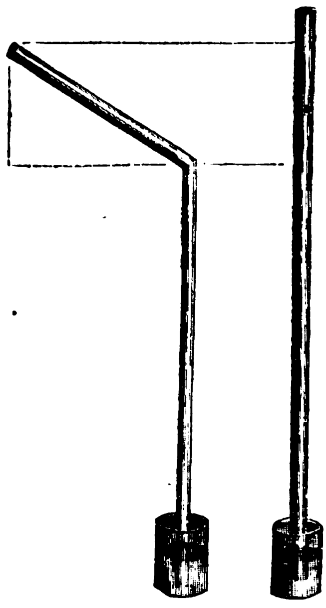
The glass tubes of which barometers are made, should have a bore of not less than one-third of an inch in diameter, and they should be perfectly clean within. To prevent their contracting any impurity before they are used, it is usual to hermetically seal both their ends at the glass-house. Being provided with a tube of this description, on preparing it for a barometer, one of its ends must be removed with a file.

Mercury in a state of great purity, is very essential to a good barometer. It is generally purified by distillation, but as this operation may not be convenient to some, we shall mention Dr. Priestley's mode of purifying it, which is remarkable for its simplicity, and has an excellent effect:—Let a strong 10 or 12 ounce phial, with a ground stopper, be a quarter filled with the mercury to be purified; put in the stopper, hold the bottle inverted with both hands, and shake it violently, by striking the hand that supports it against the knee. After twenty or thirty strokes, take out the stopper, and blow into the phial with a pair of bellows, to change the air. If the mercury is not pure, the surface will become black in a short time, and if very foul, a black coat will coagulate on the surface. Invert the phial, stopping it with the finger, and let out the running mercury. Put the coagulated part into a cup by itself, and press it repeatedly with the finger so as to get out the mercury entangled in it. Put both portions of mercury into the phial again, and repeat the process till no more black powder separates.

After the mercury has been thus purified from its admixture with baser metals, it should be boiled for about half an hour, to free it from the moisture which it is apt to contain. It may then, when nearly cool, be poured into the tube till it reaches to within two inches of the top; then to free it from the air, hold it with the sealed end lowest, in an inclined position over a chafing-dish, placed near the edge of a table, in order that all parts of the tube may be exposed successively to the action of the fire, by moving it obliquely over the chafing-dish. The sealed end is to be first gradually presented to the fire, and the other parts in slow succession. The air, if any be contained in the tube along with the mercury, will by this means be expanded, and rising to the top of the tube, will escape. The tube must now be filled to the brim, the open end stopped with the finger, and plunged into a bason of mercury. The finger must then be taken away, and the tube being held vertically, the mercury in it will remain suspended at the height of about 29 or 30 inches, or indeed, whatever balances the pressure of the atmosphere at the time.

The accompanying engraving exhibits an arrangement for removing the air from the mercury, by the agency of a pump. The lower disk represents the pump-plate, on which is placed a glass receiver. The barometer tube is kept air tight by a collar of leathers, and the lower extremity dips into a cup of mercury. Now it will be obvious that as soon as the pump is worked, and the receiver exhausted, if we readmit the air, the mercury will be driven up purified of the air which otherwise adheres in considerable quantities.

It may be proper to add, that even in the most perfect barometer, an atmosphere of mercury occupies the upper part of the tube, and independent of that defect, air is usually found to pass down the external surface, and thus destroy the perfection of the vacuum.



A barometer constructed on the principles we have now been describing, but in the simplest form, is shown in the engraving, and beside it is placed another, which possesses some advantages over that instrument. The straight tube is supposed to be of the ordinary length, and possessing a range of three or four inches; the bent tube, on the contrary, offers a range of nearly double that amount. It is called the *angular* barometer, and the only defect which is found in this form arises from the increased friction of the mercury in the tube.

The mercury in the barometer is seldom to be seen so low as 28 inches, or higher than 30½. It indicates as follows:—

31 inches . . . Very dry weather, hard frost.
30½ . . . . . . Settled fair, settled frost.
30 . . . . Fair, frost.
29½ . . . . . . Changeable.
29 . . . . Rain, snow.
28½ . . . . . . Much rain, much snow.
28 . . . . Stormy weather.

In January, 1822, the mercury fell to 28, which is said to have been the lowest ever remarked in England. By the fall, a pressure equal to 2,000lbs. was removed from each person's body, yet probably no individual was at the time conscious of it. The maximum height of the mercurial column is about nine o'clock A. M.; the mean at twelve, and the minimum at three P. M. If the column rise from nine A. M. to three P. M. it indicates fine weather; if it fall during that interval, rain may be expected.

We have now to call the reader's attention to a series of observations by Mr. Walker, a knowledge of which will materially facilitate our acquaintance with the instrument, and its uses.

1. The barometer rising, may be considered as a general indication that the weather, comparatively with the state of it at the time of observation, is becoming clearer.

2. The atmosphere apparently becoming clearer and the barometer above *rain*, and rising, show a disposition in the air for fair weather.

3. The atmosphere becoming clear, and the barometer above *changeable*, and rising, indicate fair weather.

4. The atmosphere clear, and the barometer near *fair*, and rising, denote continued fair weather.

5. Our prognostic of the weather is to be guided relatively, thus: if notwithstanding the sinking of the barometer, little or no rain follow, and it afterwards rise, we may expect continued dry weather.

6. If, during a series of cloudy rainy weather, the barometer rise gradually, though yet below rain, especially if the wind change from the south or west towards the north or east points, clear and dry weather may be expected.

7. The weather for a short period, viz. from morning until evening, may commonly be foretold with a considerable degree of certainty. If the barometer has risen during the night, and is still rising, the clouds are high and apparently dispersing, and the wind calm, especially if it be in or about the north or east points, a dry day may be confidently expected. The same rule applies for predicting the weather from evening till morning.

8. During the increase of the moon there seems to be a greater disposition or effort in the air for clear dry weather, than in the wane; but this disposition does not usually commence till about three or four days after the new moon, and ceases about three or four days after the full moon.

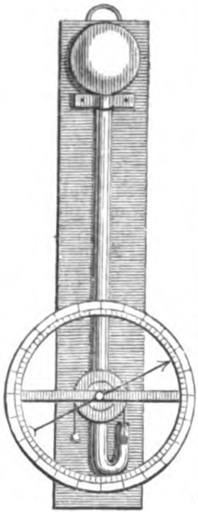
9. The barometer should be observed occasionally thrice in the day, or oftener when the weather is changeable, in order to notice whether the mercury be stationary, rising, or sinking; for, from this circumstance, together with the direction of the wind and the apparent state of the air at the time, is information to be collected; and a continuance of the same, or a sudden change of the weather, to be foreseen.

Lastly, observe always, the higher the mercury shall stand in the scale in each instance, and the more regularly progressive its motion shall be, the stronger will be the indication: likewise, the more the wind inclines towards the north or east points, the greater will be the disposition in the air for fair weather. The indications of rainy weather will obviously be the direct reverse of those rules which predict fair weather. Frost is indicated in winter by the same rules that indicate fair weather; the wind being in or about the north or east points, and the thermometer sinking towards 30. A fall of snow seldom comes without a previous frost of some duration, and is indicated by the sinking of the barometer; especially if the mercury be below *changeable*, and the thermometer at or near the freezing point. When the temperature of the air is about 35, snow and rain sometimes fall together; at a warmer temperature than 35 it seldom snows, or rains at a colder temperature. Thunder is presaged by the same rules which indicate rain, accompanied by sultry heat; the thermometer being up to 75. Storms, hurricanes, and high winds, are indicated by the barometer falling suddenly, or sinking considerably below *much rain*. The barometer is known to be rising or sinking, by the mercury having either a convex or concave surface; or by the perceptible rise or descent of the mercury, if at the time of observation the barometer be gently rapped. If at any time the weather should differ widely from the indications of the barometer, it may be presumed, as it is sometimes known to happen, that a particular spot is affected by local circumstances. After a long-continued series of wet weather, we may, when the weather becomes fine, expect an uninterrupted continuance of dry weather. If, after a long series of wet weather, the barometer rise above *changeable*, and the wind veer steady to the north or east points, a continued duration of fair weather may be expected. Slow and progressive variations in the barometer, with a fixed and steady state of the wind, indicate permanency with the change. The barometer standing at or above *fair*, denotes generally fair weather, although the atmosphere wear at the time an unfavourable aspect.

The greater coincidence there is of the circumstances enumerated in the rules above mentioned, the stronger may our confidence be in the expectation of fair weather; and in the continuance of it when present, by the barometer whilst high remaining stationary, or varying but little, and the state of the atmosphere and direction of the wind disposed to be settled. In this variable climate there is no reliance to be placed on any rules beyond those above mentioned, for indicating the weather for any length of time together, or for any distant period.

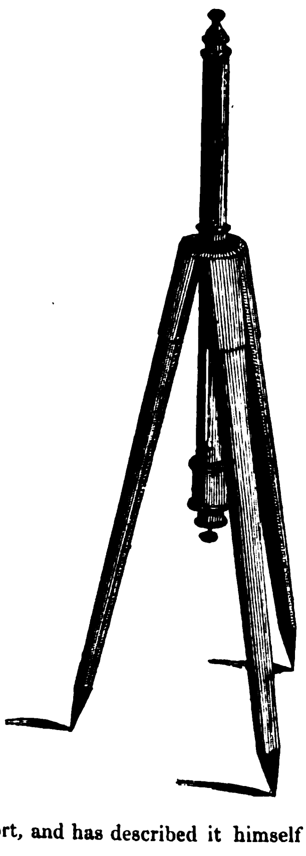
The straight tube we have already described, though it does not possess the largest range, is assuredly the most perfect form of the instrument. The *wheel barometer* is even less perfect than the diagonal one, and yet as that is the ordinary form of the weather-glass, its arrangement should be illustrated. Before doing which, it may, however, be proper to guard our readers against the purchase of instruments of this description, sold by foreign vendors about the streets of the metropolis. They are usually made in the most imperfect manner, and the mercury with which the tube is filled, adulterated with lead, which gradually discolours the glass and destroys the value of the barometer.

The accompanying engraving represents a glass tube containing mercury, having a large round head or ball, and bent upwards at the bottom. Upon the surface of the mercury in the curved leg, is placed a short glass float, loaded with the same material, with a string passing over a pulley, and balanced by another weight hanging freely in the air. As the surface of the mercury in the ball is very large, and that at the bottom of the tube comparatively small, the motion of the quicksilver, and consequently of the balance or float at bottom, will be very considerable: but as the weight moves up and down, it turns the pulley, and to that is attached a hand, or index, which passes over the divisions of a large graduated circle.



The common *portable barometer* has a small bag, for the purpose of containing the mercury, so that no part of it is exposed to the atmosphere; but the air presses upon the outside of the bag. To render the instrument perfectly portable in its frame, a screw, is used to force the mercury to the top of the tube.

Portable barometers, such as are shown in the accompanying engraving, are chiefly required for measuring the heights of mountains, and they should always be constructed in the most accurate manner. The mercury in the cistern must be raised always to the same mark or distance from the scale, in order that the divisions of the scale may indicate the real altitude of the surface of the mercury in the tube above that of the mercury in the cistern. They should also be furnished with a triangular stand, capable of supporting them in exactly a vertical position, as shown in the figure. Mr. Ramsden, an eminent philosophical instrument maker, contrived a valuable barometer of this sort, and has described it himself in the *Philosophical Transactions*. The principal parts of it are a simple straight tube, fixed into a wooden cistern, which, for the convenience of carriage, is closed with an ivory screw, and, that being removed, is open when in use. From this aperture is distinctly seen the coincidence of the gauge-mark, with a line on the rod of an ivory float swimming on the surface of the fluid metal, which is raised or depressed by a brass screw at the bottom of the cistern. From this, as a fixed point, the height of the column is readily measured on the scale attached to the frame. The thermometer is placed near the cistern. the ball of which is not inclosed within the woodwork, but left projecting. The three-legged stand, supporting the instrument when in use, serves as a case for it when inverted, and carried from place to place. Two of these barometers, made by the inventor, after the mercury in them had been carefully boiled, being suffered to remain long enough in the same situation to acquire the same temperature. usually agreed in height, or rarely differed from each other more than a few thousandth parts of an inch.



When the barometer is used for measuring the heights of mountains, or other elevations, the temperature of the mercury must be considered, as well as its elevation; because it will expand and contract with heat and cold, and the upper regions of the atmosphere are much colder than those below. The general principle of these kinds of measurement may be understood from the following illustration:—When the barometer on the surface of the earth stands at 30 inches, and the temperature is 32 Fah., it has been ascertained by trial, that taking such barometer to the perpendicular height of 87 feet, lowers the mercury about one-tenth of an inch, or will cause it to fall to 29.9; but presuming it to be raised still higher in the air, or until it descends another tenth of an inch, or stands at 29.8, it is required to know how much it has been elevated? The second stratum of air is evidently equal in weight to the first, because each has produced an equal depression of the mercury: but since, from the nature of the atmosphere, each succeeding stratum is lighter or less dense as we ascend, so the second stratum, to be of equal weight, must be of greater height than the first, and consequently the whole ascent must be more than twice 87 feet. To examine this difference, the density of the first stratum of air may be represented by the number of tenths of an inch of mercury which it is capable of supporting; and as the column was supposed to be at 30 inches high, this will be 300: for the same reason, the density of the second stratum will be represented by 299; but the weights of these two strata are equal, therefore their bulks must be inversely as their densities; and since their bases are equal, difference of bulk can only arise from difference of height; and, consequently, to obtain the thickness of the second stratum of air, or its height above the first, it will only be necessary to say 299 is to 300, as 87 feet, the height of the first stratum, is to 87.29 feet, which will be the height of the second; so that the whole distance ascended will be 174.29 feet. In like manner, if the barometer is carried upwards until the mercury falls to 29.8, then the proportion will be 298 : 300 :: 87 feet, : 87.584; or it will have ascended to the height of 261 feet and 7-8ths.

Baron; a word derived from the Latin, which signifies a *man*, but, sometimes, a *servant*. In the feudal

system of the middle ages, at first, the immediate tenant of any superior was called his *baron*. In old records, the citizens of London are so styled, and the 16 members of the house of commons, elected by the cinque-ports, are still called *barons*. The family of Montmorency called themselves, in France, *premiers barons de la chrétienté*. This name was introduced by William the Conqueror from Normandy to England, and used to signify an immediate vassal of the crown, who had a seat and vote in the royal court and tribunals, and, subsequently, in the house of peers. It was the second rank of nobility, until dukes and marquises were introduced, and placed above the earls, and viscounts also set above the barons. In Germany, the ancient barons of the empire were the immediate vassals of the crown. They appeared in the imperial court and diet, and belonged to the high nobility. But these ancient feudatories were early elevated to the rank of counts or princes. The modern barons only form a rank of lower nobility after the counts.—*Barons of the Exchequer;* four judges in England and five in Scotland, to whom the administration of justice is committed, in causes between the king and his subjects, relating to the revenue. They were formerly *barons of the realm*, but, of late, are, generally, persons learned in the laws.

BARONETS; a hereditary dignity in Great Britain and Ireland, next in rank to the peerage, originally instituted by James I., May 22, 1661. It is said that Lord Chancellor Bacon suggested the idea, and the first baronet was Sir Nicholas Bacon of Redgrave. Baronets are created by patent, under the great seal, and the honour is generally given to the grantee and the heirs male of his body lawfully begotten, though sometimes it is entailed on collaterals. From the preamble of the original patent, it appears that the order was created to get money for the support of soldiers in Ireland, each baronet, on his creation being obliged to pay into the treasury a sum little less than 1100*l*. In 1823, there were 661 baronets in England. Precedency is given to baronets before all knights, except those of the Garter, bannerets created on the field, and privy counsellors.

Baronets of Ireland; an order instituted by James I., for the same purpose, and with the same privileges, as the baronets of England. Since the Union, in 1801, none have been created otherwise than as baronets of the United Kingdom. A hereditary dignity, somewhat similar to knighthood, appears to have been conferred, in this country, even in very ancient times.

Baronets of Nova Scotia, and Baronets of Scotland. Charles I. instituted this order in 1621, for the purpose of advancing the plantation of Nova Scotia, in which the king granted a certain portion of land to each member of the order. Since the union, the power of the king to create new baronets within Scotland is held to have ceased.

BARRICADE, or BARRICADO; those objects which are hastily collected, to defend a narrow passage (for instance, the street of a village, a defile, a bridge, &c.), the moving of which retards the enemy, and gives to the sharp-shooters, posted behind or in its neighbourhood, an opportunity of firing upon them with effect. Waggons, harrows, casks, chests, branches of trees, beams,—in short, every thing which is at hand, is used for this purpose; and, if it is necessary that the enemy, when consisting principally of cavalry, should be checked in the pursuit, though it be but for a moment, the ammunition and baggage-waggons may be employed with effect.

Some of the most remarkable instances of the use of the barricade on record, are those which occurred during the late revolution which placed Louis Philip on the throne of France.

BARYTES; the name of one of the earths. It is procured either from the native sulphate of barytes, by exposing its powder to a red heat with charcoal, and by forming from the resulting sulphurate a nitrate, which is decomposed by heat; or from the native carbonate, by dissolving it in nitric acid, and, in like manner, subjecting it to the heat. Thus obtained, barytes has a specific gravity of 4, is of a gray colour, has a caustic taste, and slakes on exposure to the air, like lime falling to powder from the absorption of water. It is soluble in 25 parts at 60°, and in the proportion of nearly half its weight at 212°. The solution, on cooling, affords prismatic crystals. Its watery solution possesses, distinctly, alkaline properties, changing the vegetable blues to green, and acquiring a film upon its surface, when exposed to the air, from the absorption of carbonic acid. It operates as a virulent poison when taken into the stomach. To the flame of alcohol it imparts a yellow colour, which, together with its great solubility in water, serves to distinguish it from the other earths. It is useful in chemical analysis, in consequence of its property of uniting by fusion with several of the earths and metallic oxides, and rendering them soluble in acids or water.—Barytes has been decomposed by the agency of galvanism, and ascertained to be the oxide of a peculiar metal, to which Sir Humphrey Davy has given the name of *barium*. It has a white colour, with a metallic lustre, resembling that of silver. Exposed to the air, or thrown into water, it absorbs oxygen, and is converted into barytes.—Barytes combines with the acids, and forms a variety of salts, two of which, the carbonate and the sulphate, are found abundantly in nature. The first of these is called, in mineralogy, *Witherite*, from Dr. Withering, its discoverer. It is commonly fibrous or bladed in its structure, occasionally including small cavities lined with minute crystals. It is whitish, translucent, and glistening. Specific gravity, 4.3. It is composed of barytes, 78, and carbonic acid, 22. Like all the other salts of barytes (with one exception), the carbonate is a virulent poison, and has often proved fatal to domestic fowls and animals who have accidently swallowed it, about the mines where it occurs. Its principal localities are in the north of England, where it is found in lead mines: it also occurs in Stiria, Salzburg, and Siberia. It is used to obtain the pure barytes, and those salts of this earth which are employed as chemical tests, and for the purposes of scientific illustration.—The sulphate of barytes, called, in mineralogy, *heavy-spar*, is found abundantly in almost every country, usually accompanying galena, or common lead ore, of which it frequently forms a part. It is often beautifully crystallized under a variety of forms, derived from a right rhombic prism of 101° 42′, and 78° 18′, but is more generally, lamellar or compact. It presents numerous colours, of which white is the most frequent. It is translucent, and sometimes transparent, capable of being scratched by the knife, and of a specific gravity of 4.7. Like the artificial sulphate of barytes, it is insoluble, and is the only salt of this earth which is not poisonous. It consists of 67 parts barytes and 33 sulphuric acid. It is em-

ployed, though less extensively, for the same purposes as the carbonate, and was formerly used, by Mr. Wedgewood, in the manufacture of his beautiful jasper ware.—A fibrous variety of heavy-spar, called *Bolognian stone*, and which occurs, imbedded in small nodular masses, in a marl near Bologna, has the remarkable property of becoming phosphorescent by calcination.—The *artificial* sulphate of barytes, formed by adding sulphuric acid to the carbonate of barytes, is employed for the purpose of painting in water-colours, and is the most beautiful white now in use. It is known by the name of *permanent white*. The same substance is much valued for marking bottles in chemical laboratories, where the acid vapours destroy common ink, and for labelling articles kept in cellars and moist places. In order to be applied, it is mixed up with spirits of turpentine and linseed oil, to the consistence of common paint, when it is laid on with a brush. If a black marking material is preferred, this may be rendered so by the addition of a little lamp-black.—The *nitrate of barytes* is formed by dissolving the native carbonate in diluted nitric acid, and crystallizes on evaporation. It is soluble in 10 or 12 parts of water, at 60°, and in 3 or 4 parts at 212°.—The *muriate of barytes*, in like manner, is produced by submitting the carbonate to the action of dilute muriatic acid. It is much more soluble than the nitrate. Solutions of both these salts are of great importance in analytical processes, for the detection of sulphuric acid; the barytes forming, with that acid, an insoluble precipitate, while the nitric or muriatic acid neutralizes the base. The muriate of barytes is employed with advantage, as a medicine, in the treatment of scrofulous diseases, though, from its poisonous nature, great caution is requisite in its administration.

Base, in *Architecture* and *Sculpture* ; the foot, or bottom of any figure. The word base is used, generally, for any body which bears another, but particularly for that portion of the lower part of a column, which is between the shaft and pedestal (when a pedestal is used), and differs in the various orders and species of architecture. In Egyptian architecture the bases of columns are mostly simple plinths; and although Dr. Pococke exhibits the base of a column found in Egypt with several tori, yet this circumstance indicates the style to be of the time of Greek architecture prevailing in Egypt. The base of the Tuscan column consists of a torus and fillet; the Doric has none, except a plain plinth, on which it is sometimes elevated, but it is generally placed on a continued plinth or upper step of the temple, as in the temples at Thoricus, Corinth, Agrigentum, Pæstum, Athens, Sunium, and Ægina. Although, in modern times, the attic base has been given to the Roman spoliation of the Doric, yet in the best time of Roman architecture (according to Vitruvius), the Doric was used, as by its inventors, without the base. The Ionic column, in the earliest specimens, has a base, of which the height was half its diameter, and composed of a variety of members. The bases to the Corinthian and Composite orders emanate from the Attic; a torus or two more, a greater number of fillets or beads, two scotiæ, &c., are the general characteristics of these bases. Different bases have been invented, and used both by Greek as well as Roman architects for the Ionic order, but all fall short of the purity of style which characterises the Attic.

Base, or Basis ; a term in tactics, first introduced into military language by Henry von Bülow, who laboured to reduce war to mathematical principles, and to give more certain rules to the commander. By *basis*, he understands a tract of country well protected by fortresses, and from which the operations of the army proceed. The line upon which these operations are executed he calls the *line of operation;* the fortresses from which the operations begin, the *subject;* the point to be first carried, the *object*. Thus, in an offensive war of France against the south of Germany, supposing Prussia and Switzerland to be neutral, the Rhine, from Basle to Carlsruhe, would be the basis ; Strasburg, the subject ; Ulm or Ratisbon, the object; and the road from Strasburg to these places the line of operation. As Bülow thought magazines indispensible, the security of the line of operation against all attacks from the side seemed to him likewise indispensible, and he laid down the principle, that both the lines, drawn from the ends of the basis to the object, ought to meet there in a right or an obtuse angle, the last being preferable. The novelty and importance of the subject, and the severity with which Bülow criticised his opponents, gave rise to a violent dispute. In 1814, the subject was discussed in *Fragmente aus den Grundsäzen der Strategie, erläutert durch die Darstellung des Feldzugs in Deutschland*, 1796 ; a most valuable work, composed by the archduke Charles of Austria. He adopts many of the ideas of Bülow, and rejects others; and, on the whole, establishes the theory of the basis on such grounds, that every unprejudiced military man will be disposed to admit it. He also maintains, that the basis (according to his definition, a straight line, which unites several points at which the stores of the army are collected(must be covered. It ought, since the operation on one road would be dangerous, to include, if possible, several fortified places, connected by easy communications, and to run parallel with the basis of the enemy. If the troops have moved too far from the basis, a new one should be formed. The Archduke explains his principles on a supposed theatre of war in the south of Germany, and by the war which actually took place in that country in 1796, in which he distinguished himself so much. The last wars in Europe have shown the correctness of this theory, which has been acted on, more or less by generals in all ages, and the neglect of which has generally been attended with suffering and defeat. Thus the Prussians, in 1792, advanced, without paying regard to the fortresses of Metz, Thionville, Landau, &c., on one line of operation, and were nearly destroyed at Valmy ; and, for the same reason, the army of Jourdan, in 1796, was almost entirely ruined, after some unfortunate engagements. So the army of Napoleon perished in Russia, because he had not formed, before advancing to Moscow, a new basis on the Dnieper. The war in Spain, also, westward of Madrid, consisted only of detached movements of large columns, which were ineffectual, on account of the want of a proper communication. The allies also were enabled to march from all sides against Napoleon, at Leipsic, in consequence of his having neglected to form a basis at Dresden ; and they themselves were several times exposed to the greatest danger in France, from a similar neglect, when nothing but the boldness of Blücher, and the courage of our troops saved them. It may be objected, that Napoleon owed his greatest glory to campaigns in which he entirely disregarded

the basis; as those of 1806 and 1809, against Austria, and his previous campaigns in Italy; but one single great and decisive battle lost would have punished severely his neglect of this principle. And moreover, there is one rule still more important than those of tactics—to act according to the circumstances and character of the enemy, and to bring on decisive results by energetic measures, rather than to moulder away in inaction. We may remark, also, that the conquest of the capital of a large state is always a most important object, and should be aimed at as speedily as the rules of tactics will allow.

Bass; the lowest part in the harmony of a musical composition. It is the most important of all the parts, the foundation of the harmony, and the support of the whole composition.—*Figured bass* is a bass which, while a certain chord or harmony is continued by the parts above, moves in notes of the same harmony. For example, if the upper parts consist of C, E, G (the common chord or harmony of C), and while they are continued, the bass moves from C, the fundamental note of that harmony, to E, another note of the same harmony, that bass is called a *figured* bass.—*Fundamental bass* is that bass which forms the tone or natural foundation of the harmony, and from which that harmony is derived. To explain this by an example:—if the harmony consist of the common chord of C, C will be its fundamental bass, because from that note the harmony is deduced; and if, while that harmony is continued, the bass be changed to any other note, it ceases to be fundamental, because it is no longer the note from which that harmony results, and is calculated.—*Ground bass* is bass which starts with some subject of its own, and continues to be repeated throughout the movement, while the upper part or parts pursue a separate air, and supply the harmony. This kind of bass was greatly in fashion half a century ago, but has long since been rejected as an unnatural restraint upon the imagination, and productive of a monotonous melody.—*Bass clef* is the character put at the beginning of the stave, in which the bass, or lower notes of the composition, are placed, and serving to determine the pitch and names of those notes.—*Basso concertante* (Ital.) is the bass of the litle chorus; the bass which accompanies the softer parts of a composition, as well as those which employ the whole power of the band. This part is generally taken by the violoncellos.—*Bass-counter* or *contra-bass*; the under bass; that part which, when there are two basses in a composition, is performed by the double basses, the violoncellos taking the upper bass or *basso concertante*.—*Basso recitante* (Ital.); the bass of the little chorus; the same with *Basso concertante*. *Basso repieno* (Ital.); the bass of the grand chorus; that bass which joins in the full parts of the composition, and, by its depth of tone and energy of stroke, affords a powerful contrast to the lighter and softer passages or movements.

Bas-Relief. See succeeding article.

Basso-Rilievo, in *Sculpture;* that kind of sculpture in which the figures do not stand out from the ground in their full proportion: low or flat sculpture. All works in sculpture are classed as bassi-rilievi when the subjects represented are not isolated, but are adherent to the ground, whether they are of a similar or different material, and applied or fixed thereto; or form a part of the material in which they are wrought. This branch of the art is divided into three classes, called, alto-rilievo, mezzo-rilievo, and basso-rilievo.

Alto-rilievo is that relief in which the figures are entire, or nearly so, being attached only in a few places, and are relieved from the ground like the metopes of the Parthenon; mezzo-rilievo is that in which half the figure stands clear from the ground, and the other appears buried therein; and basso-rilievo, properly so called, is that in which the figures lose their projection, and are represented as nearly flat, like the Panathenæic procession of the same temple. Custom, however, has nearly abolished two of these terms; and basso-rilievo is often applied to each sort, be the projections what they may. The word anaglyphum, in the ancient writers, indicates a particular manner of this sort of sculpture, and is equivalent to the modern chasing or embossing; to which, when executed in metal, according to Cicero, was given the name of toreuma.

The true basso-rilievo, which has but small projection, requires more skill in the sculptor than that in which the projection is more considerable; because it is extremely difficult to give a natural effect to a figure which is of its proper height and size, but falls short of its real thickness. What is more difficult even than this, in the style of sculpture now under consideration, is picturesque composition in grouping the figures; because the artist cannot, as in painting, employ different back grounds remote from each other: and as the shadows in sculpture are real and not imitative, he must calculate his composition, and arrange its form for the light in which it is to be placed. The ancients used bassi-rilievi in decorating architectural designs, and in ornamenting their domestic furniture. All nations, however, in the history of the arts have used them, and they resemble in style that of their other works. The Egyptians ornamented their temples with an innumerable quantity of figures and hieroglyphics, of which the greater part have the outlines only sunk, and the area thus formed only painted; but many of them are of the class of bassi-rilievi. Their manner of executing these sculptures was singular: they first channelled an outline in the stone, and sunk it round the figure, so that it did not project beyond the original face; being, in fact, more a species of engraving than sculpture. The cabinet of the Royal Library at Paris possesses a very curious Egyptian sculpture thus wrought; and many of the same description are found in Egypt, principally on the frontispieces of the temples where the Scarabeus extends his reign.

The study of the ancient bassi-rilievi is of great service in the history of the arts; as from them may be collected many important facts of the mythology, customs, costume, &c. of the ancients. The finest collections of antique bassi-rilievi now existing, are those forming the Townly Collection, and now in the British Museum, ; the Elgin Marbles in the same place; the collections of Mr. Thomas Hope, Mr. Soane, the professor of architecture in the Royal Academy of London; and several fine casts in the Royal Academy. In Paris they had some fine antique bassi-rilievi in the Royal Museum; the Museum of the Augustins; and many private collections. The application of bassi-rilievi among the moderns is the same as among the ancients; being used in the decoration of public buildings, palaces, churches, triumphal arches, theatres, concert-

rooms, and private houses; furniture, tombs, and other subjects of ornamental architecture. The most celebrated specimens of basso-relievo (properly so called), of modern art in England, are those of the tympanum of the pediment of the East India House, by Bacon; the monument of Captain Miller, in a panel of St. Paul's Cathedral, by Flaxman: several others on the public monuments, erected in that cathedral and in Westminster Abbey, by Bacon, Banks, Bacon, jun., Rossi, Chantrey, Kendrick, Hopper, and Westmacott; and on the Continent, those of Baudurli, Ghiberti, and Lucca della Robbia, at Florence. Some of the finest bas-reliefs existing, are by Canova and Thorwaldsen. The bas-reliefs found by von Bröndstedt, Cockerell, &c., in the temple of Apollo at Phigalia, and sold to the British Museum for 15,000*l.* sterling, are celebrated, as are those on the column of Trajan.

Basset; the name of a game at cards, formerly much played, especially in France. It is very similar to the modern *faro*. Severe edicts were issued against it by Louis XIV., and it was afterwards played under the name of *pour et contre*. De Moivre, in his *Doctrine of Chances*, has calculated many problems connected with this game.

Basset-Horn, the richest of all wind instruments (called also *cornet*, by reason of its curvature), is believed to have been invented at Passau, in 1770. It was afterwards perfected by Theodore Lotz, in Presburg. It is, properly considered, an enlarged clarionet; and, notwithstanding the difference of its form, it resembles that, not only in its qualities and tone, but also as regards its intonation, the mode of holding it, and fingering; so that every clarionet-player can perform on it without practice. Besides the mouth-piece, by which the intonation is given, it is formed of five pieces—the head-piece (called the barrel), two middle pieces, the trunk and the bell, which is usually of brass. It has 15 ventages, of which four are provided with open, four with closed keys. Its compass is 3½ octaves, from lower F in the bass, to double C of the treble. It is seldom used in the orchestra; however, it is found in Mozart's Requiem and some other pieces. The basset-horn may also be used as a bass instrument.

Bassoon; an instrument which forms the natural bass to the hautboy. It is played, like that instrument, with a reed, and forms a continuation of its scale downwards. The reed is fixed to a crooked mouth-piece, issuing from the side of the bassoon. There, keys communicate to the ventages, which otherwise are too remote for fingering. It was formerly used as an accompaniment to the hautboy, from which it was termed *basson de hautbois*. But it is now so far improved with keys as to be susceptible of being played in solo. Its compass is three octaves, from double A in the bass to A in the second space of the treble; and its designation generally is the F or bass clef; yet, in the higher passages, for the more convenient arrangement of the notes, the alto, or tenor clef, is often used. It consists of four tubes, bound together like a faggot. Hence the Italians term it *fagotto*, and from them the Germans *fagott*. In music designed for wind instruments, it usually forms the bass. There is a modification of this instrument, much lower and stronger in its tones,—the bass-horn,—which, in field music, has of late been substituted for the serpent.

Bass-Viol; a stringed instrument, resembling, in form, the violin, but much larger. It has four strings and eight stops, which are subdivided into semi-stops, and is played with a bow.

Bastion (bulwark). In order to defend a place which is surrounded by a rampart and a ditch, it is necessary that every point at the foot of the rampart, in the ditch and before the citadel, should be, as much as possible, commanded by the cannon of the works. This is effected by breaking the line of fortification, so that a defence sideways may be attained. Before, and for some time after the invention of gunpowder, it was thought that towers, standing out from the wall, would answer this purpose; but these soon gave place to the spacious and projecting bastions or bulwarks, which consist of two flanks, that serve principally for the defence of the neighbouring bastions, and of two faces, which command the outworks and the ground before them. The wall between two bastions is called the curtain. These bastions are built in very different ways. Some are entirely filled with earth; some have a void space inside; some are straight, some curved, some double, some have even three or four flanks, one over the other; some have, and some have not, *fausse-brays* (see Fortification); sometimes they have casemates, destined for the retreat of the garrison, or for batteries; sometimes cavaliers, or orillons, &c. In modern times, among the fortifications built according to the system of bastions, those on the plan of Cormontaigne and the modern French works, are considered best adapted for defence. They are spacious; the flank of the side bulwark, which is perpendicular to the prolongation of the face of the principal bulwark, is not farther distant than a gunshot (300 paces) from its point; it is also straight, and orillons and other artificial contrivances are banished.

Bath. Bathing undoubtedly took place first in rivers and in the sea, but men soon learned to enjoy this pleasure in their own houses. Even Homer mentions the use of the bath as an old custom. When Ulysses enters the palace of Circe, a bath is prepared for him, after which he is anointed with costly perfumes, and dressed in rich garments. The bath, at this period, was the first refreshment offered to the guest. In later times, rooms, both public and private, were built expressly for the purpose of bathing. The public baths of the Greeks were mostly connected with the gymnasia, because they were taken immediately after the athletic exercises. The Romans, in the period of their luxury, imitated the Greeks in this point, and built magnificent baths. The following description applies both to the Greek and Roman baths:—The building which contained them was oblong, and had two divisions, the one for males, the other for females. In both, warm or cold baths could be taken. The warm baths, in both divisions, were adjacent to each other, for the sake of being easily heated. In the midst of the building, on the ground-floor, was the heating-room, by which not only the water for bathing, but sometimes also the floors of the adjacent rooms, were warmed. Above the heating-room was an apartment in which three copper kettles were walled in, one above another, so that the lowest was immediately over the fire, the second over the first, and the third over the second. In this way, either boiling, lukewarm, or cold water could be obtained. The water was carried, by separate pipes, provided with cocks, from these

kettles into the bathing-rooms, and a fresh supply was immediately poured into the kettles from a reservoir. Close to the heating-room were three separate rooms on each side, for the hot, the lukewarm, and the cold bath. The bathing-rooms had, in the floor, a bason of mason-work, in which there were seats, and round it a gallery, where the bathers remained before they descended into the bath, and where, also, the attendants were. There was also a sweating-room, which was heated by means of flues, and was called *laconicum*. This room had an opening in the ceiling, through which the light fell, and from which was suspended a brazen plate, that could be raised and let down at pleasure, to increase or lessen the heat. For undressing, for receiving the garments, and for anointing after bathing, there were different rooms; and connected with the bath were walks, covered race-grounds, tennis-courts, and gardens. These buildings, together with a number of bathing-rooms, were necessary for a public bath, which was adorned with splendid furniture, and all the requisites for recreation, and resembled, in its exterior appearance, an extensive palace. Roman luxury, always in search of means for rendering sensual enjoyments more exquisite, in later times, built particular conduits for conducting sea-water to the baths, used mountain snow, and enlarged these establishments in such a way that even their ruins excite admiration. (See Wichelhausen, *On the Baths of the Ancients*, Mannheim, 1807.) Among the Europeans, the Russians have peculiar establishments for bathing, which are visited by all classes of the people during the whole year. The Russian bath consists of a single hall, built of wood. In the midst of it is a powerful metal oven, covered with heated stones. Round about there are broad benches. In entering this hall, you encounter such a heat, that one who is not accustomed to it can bear it but a few moments. Those, however, who can endure it for some time, undress and stretch themselves on a mattress upon one of the benches. Cold water is then poured on the heated stones; a thick, hot steam rises, which envelopes the bather, and heats him to such a degree, that the perspiration issues from his whole body. The thermometer, in this steam, usually rises to 40° or 50° Réaumur (122° to 142° Fah.). After the Russian has enjoyed his bath in this way, he is gently whipped with wet birch rods, rubbed with soap, in order to lessen the perspiration, and, afterwards, washed with lukewarm and cold water; of the latter some pailsfull are poured over his head; or else he leaps, immediately after this sweating-bath, into a river or pond, or rolls in the snow. The Russian of higher rank takes, after his bath, a draught of English ale, white wine, toasted bread, sugar and citrons, and rests upon a bed. The common Russian, after having cooled himself in the snow, drinks some brandy, and goes again to his work. The people regard these baths as a necessary of life, and they are to be found in every village. They are also met with in Finland.—Among the Asiatics, baths are in general use. The Turks, by their religion, are obliged to make repeated ablutions daily: besides these, men and women must bathe in particular circumstances and at certain times. For this purpose, there is, in every city, a public bath connected with a mosque; and rich private persons possess private bath-houses, adorned with all the objects of Asiatic luxury. Besides these baths, the Turks have also the dry-bath of the ancients. The buildings which they use for this purpose, are built of stone, and usually contain several rooms, the floors of which are of marble. These rooms are heated by means of pipes, which pass through the walls, and conduct the heated air to every part in the most perfect manner. After undressing, they wrap themselves up in a cotton coverlet, put on wooden slippers, in order to defend the feet against the heat of the floor, and then enter the bath-room. The hot air soon produces a profuse perspiration; upon which they are washed, wiped dry, combed, and rubbed with a woollen cloth. At last, the whole body is covered with soap, or some other application, which improves the skin. After this bath, they rest upon a bed, and drink coffee, sherbet, or lemonade. The Turkish ladies daily bathe in this manner; the men not so frequently. A peculiar kind of baths is used in the East Indies, of which Anquetil gives the following account:—An attendant stretches the bather upon a table, pours over him warm water, and begins, afterwards, with admirable skill, to press and to bend his whole body. All the limbs are extended, and the joints made to crack. After he has done with one side, he goes on with the other; now kneels upon the bather; now takes hold of his shoulders; now causes his spine to crack, by moving the vertebræ; now applies gentle blows to the fleshy and muscular parts. After this, he takes a cloth of hair, and rubs the whole body, removes the hard skin from the feet with pumice-stone, anoints the bather with soap and perfumes, and finishes by shaving and cutting his hair. This treatment lasts about three-quarters of an hour, and produces the greatest refreshment. An agreeable feeling pervades the whole body, and ends with a sweet slumber of several hours. Public baths are common in Europe, and there are at present few cities without them. Medicine has been employed to increase the wholesome effects of baths by various compositions and methods of application. Baths are distinguished by the nature of the fluid, by the degree of heat, and by their influence upon the body. They are prepared with water, milk, wine, &c.; are of different temperatures; and herbs, iron, soap, and other substances are mixed with them, as the purpose requires. There are, also, baths of earth, sand, air, vapour, and electric baths. They are applied either to the whole body, or only to a single part. The shower-bath affords an agreeable and healthful mode of bathing, and much use is made of it in medicine. Mineral baths are those, the water of which naturally contains mineral ingredients.

Bath, *Knights of the*; a military order of England, concerning the origin of which antiquaries differ. It is certain that Henry IV., on the day of his coronation, conferred the degree upon 46 knights. From that time, the kings of England have bestowed this dignity previous to coronations, after births and marriages of the royal issue, &c. Charles II created several knights of the Bath, but after his time, the order fell into neglect, till 1725, when George I. revived it. By the book of statutes then prepared, the number of knights was fixed at 38, viz. the sovereign, and 37 knights-companions. The king allowed the chapel of King Henry VII., in Westminster Abbey, to be the chapel of the order. The Dean of Westminster is dean of the order. An esquire of the order is allowed to hunt and fish in the king's roy-

alty, and is exempted from serving in the office of high sheriff, and every parochial office. *K. B.* is the abbreviation for *Knight of the Bath*.

BATISTE; cambric; a very fine, thick, white, linen cloth. It is made of the best white flax, called *ramé*, which is cultivated in a district of France. In the 13th century, this manufacture is said to have been brought into vogue by Baptista Chambrai, in Flanders, and the linen afterwards received from him the name of *batiste*, or cambric (*toile de Chambrai*.) Others think that the first appellation is derived from the fine linen which we receive from India, where it is called *bastas*. Different kinds of batiste are called *linons*, *claires*, *cambrics*, &c., and manufactured not only in France and the Netherlands, but also in Switzerland, in Bohemia, and Silesia. The best come from India. (See CAMBRIC.)

BATTERING-RAM, see ARIES.

BATTERY, in the *military art*; 1. any raised place in which cannon are planted; 2. all the lines of a fortress, behind the parapets of which are cannon. They are erected in the open field, in citadels, on a lake or the sea, before a place which is to be besieged, &c. With regard to the kind of artillery, they are distinguished into cannon, howitzer, mortar, &c. With regard to their object, they are divided into breach batteries, used to attack the faces or salient angles of the bastion or ravelin, in order to make an accessible breach; batteries *en echarpe*, or oblique batteries, which are erected beside the breach batteries, under an angle of 20 to 30 degrees, in order to batter a breach obliquely; *ricochet* batteries, which command the enemy's lines, so that the balls roll along the whole length of the rampart, and render it insecure, &c. Their position is perpendicular to the line which is to be enfiladed. Mortar batteries have the parapets inwards, and no embrasures. In respect to their position, they are divided into horizontal, raised, and sunk batteries. The disposition of floating batteries may be various. Such a battery commonly consists of a raft, in the middle line of which cannon are placed, having before them breastworks made of bags of wool. The raft is fastened by a strong cable, to a beam or anchor, round which it is to be moved, and brought, by the aid of oars or rudders, to the proper place. In experimental physics, *battery* is a combination of several jars or metallic plates, to increase the effect of electricity and galvanism. (See ELECTRICITY.)

BATTLE. The object of a war may be obtained in two different ways: either one party forces the enemy, by skilful manœuvres, marches, demonstrations, the occupation of advantageous positions, &c., to quit the field (which belongs to the province of *strategy*); or the hostile masses approach each other (by design or by chance), so that a battle becomes necessary to determine which shall keep the field. The rules for insuring a successful issue, whether they respect the preparations for the conflict, or the direction of the forces when actually engaged, belong to *tactics*, in the narrower sense of the word. *Strategy* also shows the causes which bring armies together, and produce battles without any agreement between the parties. It belongs not to this article to explain this point. It may be sufficient to say, in general, that armies in their marches (and consequently in their meeting), are chiefly determined by the course of the mountains and rivers of a country. In ancient times and the middle ages, the battle-ground was often chosen by agreement, and then the battle was a mere trial of strength, a duel *en gros*; but, in our time, such trifling is done away.

War is now carried on for the real or pretended interest of a nation, or a ruler who thinks or pretends that his interest is that of the nation. Wars are not undertaken for the purpose of fighting, and battles are merely the consequence of pursuing the purpose of the war. They arise from one party's striving to prevent the other from gaining his object. Every means, therefore, of winning the battle is resorted to, and an agreement can hardly be thought of. In this respect, a land battle is entirely different from a naval battle. The former is intended merely to remove an obstacle in the way of gaining the object of the war; the destruction of the enemy, therefore, is not the first thing sought for. The views of one party can often be carried into effect with very little effusion of blood; and if a general can obtain the same end by manœuvring as by a battle, he certainly prefers the former. But the object of a naval engagement is, almost always the destruction of the enemy; those cases only excepted, in which a fleet intends to bring supplies or reinforcements to a blockaded port, and is obliged to fight to accomplish its purpose.—As the armies of the ancients were not so well organized as those of the moderns, and the combatants fought very little at a distance, after the battle had begun, manœuvres were much more difficult, and troops when actually engaged, were almost entirely beyond the control of the general. With them therefore, the battle depended almost wholly upon the previous arrangements, and the valour of the troops. Not so in modern times. The finest combinations, the most ingenious manœuvres, are rendered possible by the better organization of the armies, which thus, generally at least, remain under the control of the general. The battle of the ancients was the rude beginning of an art now much developed. It is the skill of the general, rather than the courage of the soldier, that now determines the event of a battle. There is, probably, no situation which requires the simultaneous exertion of all the powers of the mind more than that of a general at the decisive moment of a battle. While the soldier can yield himself entirely to the impulse of his courage, the general must coolly calculate the most varied combinations; while the soldier retreats, the general must endeavour to turn the tide of battle by his ardour or his genius. Daring courage, undaunted firmness, the most active and ingenious inventon, cool calculation and thorough self-possession, amid scenes of tremendous agitation, and under the consciousness that the fate of a whole nation may depend on him alone in the trying moment,—these are the qualities which a good general cannot dispense with for a moment. If it is the character of genius to conceive great ideas instantaneously, military genius is, in this respect, the greatest. Great generals have therefore been, in all ages, the objects of admiration; and as a great artist may be no example in a moral point of view, although we admire the genius displayed in his productions, so we cannot but bestow the same kind of admiration on the high intellectual gifts of a great general. Few situations, therefore, enable a man to acquire higher glory, than that of a great commander in a good cause.—If troops meet accidentally, and are thus obliged to fight, it is called a *rencontre*. Further, battles are distinguished into *offensive* and *defensive*.

Of course, a battle which is offensive for one side, is defensive for the other. Tacticians divide a battle into three periods—that of the disposition, that of the combat, and the decisive moment. The general examines the strength, reconnoitres the position, and endeavours to learn the intention of the enemy. If the enemy conceals his plan and position, skirmishes and partial assaults are often advisable, in order to disturb him, to obtain a view of his movements, to induce him to advance, or with the view of making prisoners, who may be questioned, &c. Since the general cannot direct all these operations in person, officers of the staff and aids assist him ; single scouts or small bodies are sent out, and spies are employed. Any person or thing (ministers, peasants, shepherds, maps, &c.), which can afford information of the enemy, or the ground on which the battle is likely to take place, is made use of for obtaining intelligence, by force or otherwise.

According to the knowledge thus acquired, and the state of the troops, the plan of the battle, or the disposition, is made; and here military genius has an opportunity to display itself. There is an immense difference between the quick, clear, and ingenious disposition of a great general, which shows the leading features of the plan to every commander under him, and provides for all cases, favourable or unfavourable, with a few distinct touches, without depriving the different commanders of freedom of action, and the slow, indistinct, minute, and after all, inaccurate dispositions of a feeble commander. Napoleon's dispositions are real masterpieces. Like a great artist, he delineates, with a few strokes, the whole character of the battle; and as the disciples of Raphael assisted in the painting of his pictures, but necessarily worked in the great style of their master, which his first lines gave to the picture, so all the skilful generals under Napoleon laboured for the accomplishment of one great end, sometimes disclosed to them, sometimes concealed in the breast of the commander. To the disposition also belongs the detaching of large bodies which are to co-operate in the battle, but not under the immediate command of the chief. The plan of the battle itself, the position of the troops, &c., is called the *order of battle* (*ordre de bataille*). This is either the parallel, or the enclosing (if the enemy cannot develope his forces, or you are strong enough to outflank him), or the oblique. When each division of troops has taken its position, and received its orders, and the weaker points have been fortified (if time allows it), the artillery placed on the most favourable points, all chasms connected by bridges; villages, woods, &c., taken possession of, and all impediments removed as far as possible (which very often cannot be done, except by fighting), then comes the second period—that of the engagement. The combat begins, either on several points at a given signal, as is the case when the armies are very large, and a general attack is intended; as, for instance, at Leipsic, where three fire-balls gave the signal for battle on the side of the allies; or by skirmishes of the light troops, which is the most common case. The artillery endeavours to dismount the batteries of the enemy, to destroy his columns, and, in general, to break a passage, if possible, for the other troops. The forces, at the present day, are brought into action mostly in columns, and not as formerly, in long, but weak lines. Here the skill of the commanders of battalions is exerted. Upon them rests the principal execution of the actual combat. The plans and order of a general reach only to a certain point; the chiefs of battalions must do the great work of the battle. Before the battle, the general places himself upon a point, from which he can see the conflict, and where he can easily receive reports—upon a hill, in a windmill, &c. Sometimes, if there is no such favourable point, a staging is erected. Napoleon stood upon such a one in the battle of Waterloo. A few men are near him, as his body-guard; others take charge of the plans and maps; telescopes are indispensable. He often sends one of his aids to take instant command of the nearest body of cavalry, in order to execute an order which must be carried into effect quickly. He receives the reports of the generals under him, and gives new orders; disposes of the troops not yet in action ; strengthens weak points; throws his force upon the enemy, where he sees them waver ; or changes if necessary, with a bold and ingenious thought, the whole order of battle. The general now uses every means to bring on the third period of the battle—the decisive moment. This cannot always be the result of combinations. It often takes place much sooner than was expected; it is often protracted by accidents, want of energy on the part of the commanders, &c.—Sometimes all the operations are drawing to the end which the general has been aiming to attain, when an unforeseen accident suddenly gives a new impulse to the enemy. Victory or defeat depend now upon one moment, one happy idea. Perhaps it is all important to break, at once, the enemy's centre; perhaps to concentrate the destructive power of the artillery, and, sweeping away some obstacle, to send, as Napoleon often did, a torrent of cavalry upon a certain point. Any thing which can carry disorder into the ranks of the enemy is of great use. If he begins to waver, or to retreat in order, or fly in disorder, it is always necessary to follow up the victory with all possible vigour and celerity. This is as important as victory itself. Napoleon was, till the last war in Germany, a master in this particular. There are three maxims as important for the general as they are simple:—1. Know your enemy, his strength and intentions: 2. make all the operations and manœuvres of the parts coincide, as much as possible, with the great plan of the battle; 3. pursue victory to the utmost. It is also a maxim, in regard to battles, as well as to the conduct of war generally, to make the enemy conform to your plans, and to avoid the necessity of accommodating yourself to his. (See the second division of this work, in which examples will be given illustrative of the most celebrated engagements in ancient and modern times.)

BATTLE AXE; a weapon much used in the early part of the middle ages, particularly by the people who fought on foot. It was not uncommon, however, among the knights, who used also the mace, a species of iron club or hammer. Both are to be seen in the different collections of old arms in Europe. Both these weapons, and another kind, called in German *Morgenstein* (morning star), consisting of a staff, having an iron ball at the end, with cross iron spikes, served to give stunning blows, whose force was felt through the iron armour of the knights. Knights used chiefly the *Morgenstein* and the mace. The Greeks and Romans did not employ the battle-

axe, though it was found among contemporary nations. In fact, the axe is one of the earliest weapons, its use, as an instrument of domestic industry, naturally suggesting its application for purposes of offence; but, at the same time, it will always be abandoned as soon as the art of fencing, attacking, and guarding is the least cultivated; because the heavier the blow given with this instrument, the more will it expose the fighter. It is a weapon which affords hardly any guard, and it never would have remained so long in use in the middle ages, had it not been for the iron armour, which protected the body from every thing but heavy blows. In England, Ireland, and Scotland, the battle-axe was much employed. At the battle of Bannockburn, king Robert Bruce clove an English champion down to the chine with one blow of his axe. A blow of equal force was given by a Suabian knight, in the Levant, in presence of the German emperor. The Lochaber axe remained a formidable implement of destruction in the hands of the Highlanders nearly to the present period, and is still used by the city guard of Edinburgh in quelling riots, &c.

Battle-Piece; a painting which represents a battle, exhibiting large masses of men in action. The armour of the ancients, and the whole array and action of their battles, afford subjects much more favourable to the artist than the straight lines, or condensed columns, and the fire-arms of the moderns. A painter of battle-pieces ought to have an accurate knowledge of the appearance of horses and men, and, if possible, to have seen a battle, as few persons are able to form from hearsay an accurate idea of such a scene. Some of the greatest pieces of this kind are, the battle of Constantine, of which the cartoons were drawn by Raphael, and which was executed by Giulio Romano; Lebrun's battles of Alexander, and the battles of the Amazons, by Rubens. From these may be distinguished the skirmishes, surprises, &c., which are represented with so much skill by Antonio Tempesta, John Snellink, Jos. van der Velde, John Asselyn, Peter Sneyers, Robert van Hoek, Fulcone, called *oracolo delle battaglie*, James Courtois, Francis van der Meulen, Philip Wouvermann, Charles Breydel, Henry Verschuuring and, George Philip Rugendas.

Bayonet. This is the name of the iron blade, formed like a dagger, and placed upon the muzzle of the musket, which is thus transformed into a thrusting weapon. It was probably invented, about 1640, in Bayonne, and was used in the Netherlands, in 1647, but was not universally introduced until after the pike was wholly laid aside, in the beginning of the 18th century. Since the general war in Europe, some officers have adopted the idea of former military writers (for instance, Guibert), of increasing the efficiency of the bayonet by a more regular exercise of the infantry in its use. A Saxon captain, von Selmitz, has the merit of having first developed this idea in a systematic treatise. As cavalry are often counted by horses, infantry are sometimes counted by bayonets.

Beam, in *Architecture;* a long and large piece of timber, into which the feet of the principal rafters, king posts, &c., are framed; intended also to tie the walls of the building together; contradistinguished from those used in the floors, which are called girders, and those which are used to support the fronts of houses, which are called brestsomers.

Bear, in *Astronomy;* a name given to two constellations called the greater and the lesser bear, or ursa major and minor.

The polar star is said to be in the tail of the lesser bear; this star is never above two degrees distant from the north pole of the world. (See Ursa.)

Beer; a fermented liquor, made from any farinaceous grain; but generally from malted barley. This is effected by extraction with water and fermentation. With this view, a quantity of malt freed from its germs, and sufficient for one brewing, is coarsely bruised by grinding, and being placed in the mash-tub, after being well mixed with tepid water, its temperature is considerably raised. When the whole mass has been well stirred, and then allowed to subside, the extract (mash), or sweet-wort, is brought into the boiler; and the malt remaining in the tub, is once more extracted by infusion with hot water. This second extract, treated in like manner, is added to the first, and both are boiled together. This clear infusion is now drawn off, and called boiled wort. To render the beer fitter for digestion, as well as to fit it for the market, hops are added. After which it ought to be quickly cooled, to prevent its transition to the acetous fermentation, which would ensue, if it were kept too long at a high temperature. On this account, the wort is transferred into the cooler; where it is exposed with a large surface to cold air, and from this to the fermenting-tub, that by the addition of a sufficient portion of recent yeast it may begin to ferment. When this fermentation has proceeded to a due degree, and the yeast ceases to rise, the beer is conveyed into casks, placed in cool cellars, and the fermentation completed. It now becomes what is called "barrelled beer," with the precaution of occasionally filling up the vacancy caused in the vessel by evaporation. Or, the beer is bottled before it has done fermenting; and the bottles are stopped a little before the fermentation is completely over. By so doing, the bottled beer is rendered sparkling. In this state it frequently bursts the bottles, by the disengagement of the carbonic acid gas which it contains; and it effervesces like champaign, when brought into contact with air, on being poured into another vessel.

Beer, well prepared, should be limpid and clear, possess a due quantity of spirit, excite no disagreeable sweet taste, and contain no disengaged acid. By these properties it is a species of vinous beverage, and is distinguished from wine, in the strict sense, and other liquors of that kind, by the much greater quantity of mucilaginous matter which it has received by extraction. "Brown beer" derives its colour from malt highly dried in the kiln, and its bitterish taste from the hops. "Pale beer" is brewed from malt still lower dried.

In the above notice we have confined ourselves to the simplest process for the brewing beer. *Porter* fitted for the London market is a very different compound, and will be described under that head.

Bell, a vibrating instrument, ranked by musicians among the number of musical instruments of percussion. The parts of a bell are the body or barrel, the clapper within side, and the suspending links. It is usually formed of a compound, called bell-metal. The thickness of its edges is usually 1-15th of its diameter, and its height twelve times its thickness. The bell-founders have a diapason, or bell-scale, with which they measure the size, thickness, weight, and tone of their bells.

The sound of a bell arises from a vibratory motion of the parts thereof, much like that of a musical chord. The stroke of the clapper, it is obvious, must change the figure of the bell, and from a round make it oval; but the metal having a great degree of elasticity, that part which the stroke drove farthest from the centre will fly back again, and this even somewhat nearer the centre than before; so that the two points, which before were the extremes of the longer diameter, now become those of the shorter. Thus, the circumference of the bell undergoes alternate changes of figure, and gives that tremulous motion to the air, in which sound consists.

M. Penault maintains, that the sound of the same bell or chord, is a compound of the sound of the several parts thereof; so that where the parts are homogeneous, and the dimensions of the figure uniform, there is such a perfect mixture of all these sounds, as constitutes one uniform, smooth, even sound; and the contrary circumstances produces harshness. This he proves from the bell's differing in time according to the part you strike; and yet strike it any where, there is a motion of all the parts. He therefore considers bells as composed of an infinite number of rings; which, according to their different dimensions, have different tones, as chords of different lengths have; and when struck, the vibrations of the parts immediately struck determine the tone being supported by a sufficient number of consonant tones in the other parts. Mr. Hawksbee, and others, have found, by experiment, that the sound of a bell struck under water, is a fourth deeper than in the air; though Mersennus says, it is of the same pitch in both elements. This writer has treated largely of the different metals of which bells are formed, of their figure, crassitude, and degrees of ponderosity, as they respect each other in a given series.

Bells are observed to be heard farther, placed on plains, than on hills; and still farther in valleys, than on plains: the reason of which it will not be difficult to assign, if it be considered that the higher the sonorous body is, the rarer is its medium; consequently the less impulse it receives, and the less proper vehicle it has to convey it to a distance. There is a curious observation in a paper of M. Reaumur's, in the *Memoirs of the Paris Academy*, relating to the shape most proper for bells, to give them the loudest and clearest sound. He observes, that as pots, and other vessels more immediately necessary for the service of life, were doubtless made before bells, it probably happened, that the observing these vessels to have a sound when struck, gave occasion to making bells, intended only for sound, in that form: but that it does not appear that this is the most eligible figure; for lead, or metal, which is, in its common state, not at all sonorous, yet becomes greatly so on being cast into a particular form, and that very different from the common shape of bells.

In melting lead for the common occasions of casting in small quantities, it is usually effected in an iron ladle; and as the whole is seldom poured out, the remainder, which falls to the bottom of the ladle, cools into a mass of the shape of that bottom. This is, consequently, a segment of a sphere, thickest in the middle, and thinner towards the edges: nor is the ladle any necessary part of the operation, since, if a mass of lead be cast in that form in a mould of earth or sand, in any of these cases it is found to be very sonorous. Now, if this shape alone can give sound to a metal, which in other forms is perfectly mute, how much more must it necessarily give it to other metals naturally sonorous in whatever form. It should seem that bells would much better perform their office in this than any other form, and that it must particularly be a thing of great advantage to small bells of common house-clocks, which are required to have a shrill note, and yet are not allowed any great size. M. Reaumur very judiciously observes, that if our forefathers had opportunities of being acquainted with the sound of metals in this shape, we should probably have had all our bells at present of this form.

With regard to the origin of bells, those of a small size are very ancient; but those of a large bulk, hung in towers and hung by ropes, were introduced at a much later period. Among the Jews, it was ordained by Moses, that the lower part of the blue robe which was worn by the high-priest in religious ceremonies, should be adorned with pomegranates and gold bells intermixed at equal distances.

The kings of Persia are said to have had the hem of their robes adorned, like that of the Jewish high-priests, with pomegranates and gold bells. The Arabian princesses wear on their legs large hollow gold rings, filled with small fruits, which sound like bells, when they walk; and these, with similar appurtenances, give notice that the mistress of the house is passing, so that the servants of the family may behave with respect, and strangers may retire to avoid seeing the person who advances. Calmet supposes, that it was with some such design of giving notice that the high-priest was passing, that he wore little bells at the hem of his robe; and it was also a kind of public notice that he was about to enter into the sanctuary.

In the court of the king of Persia, no one entered the apartments without some warning; and thus the high-priest, when he entered the sanctuary, desired permission to enter by the sound of his bells, and in so doing, he escaped the punishment of death annexed to an indecent intrusion. The prophet Zacharias speaks of bells of the horses, which were probably hung to the bridles or foreheads of war-horses, that they might thus be accustomed to noise. Among Christians, they were first employed to call together religious congregations, for which purpose runners had been employed before. Afterwards the people were assembled by the sound of little pieces of board struck together; hence called *sacred boards.* To the present day, the Catholics use such boards in Passion-week and Lent, because the noise of bells seems to them unsuited to the solemnity of the season. On the first day of Easter the bells ring again, and the return of the accustomed sound produces a very cheerful effect. Paulinus, bishop of Nola in Campania, is said to have first introduced church bells, in the fourth century, and thence the Latin names of the bell, *campana* and *nola,* are said to have originated. In the sixth century bells were used in the convents; they were suspended on the roof of the church in a frame. Towards the end of this century bells were placed on some churches at the expense of certain cities. About 550 they were introduced into France. Pope Sebastian, who died in 605, first ordered that the hours of the day should be announced by striking the bell, that people might better attend to the *horæ canonicæ*, that is, to the hours for

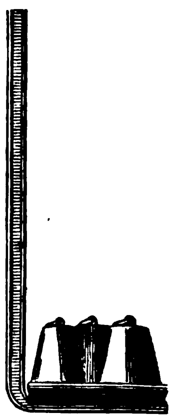
singing and praying. In 610, Clothaire besieged Sens, when Lupus, bishop of Orleans, ordered the bells of St. Stephen to be rung. The sound so frightened Clothaire, that he gave up the siege. In the eighth century, the custom of baptizing and naming bells began. Church bells were probably introduced into England soon after their invention. They are first mentioned by Bede, about the close of the seventh century. In the East they came into use in the ninth century; in Switzerland, in 1020; at what period they were brought into Germany is uncertain. In the 11th century the cathedral at Augsburg had two bells. The same spirit which induced people to build immense minsters, and to apply their wealth n ornamenting the places of worship, made them vie with each other in the size of their bells. The great bell of Moscow, cast in 1653, in the reign of the empress Anne, is said by Mr. Clarke, to be computed to weigh 443,772 lbs. A bell in the church of St. Ivan, in the same city, weighs 127,836 lbs.; another, 356 cwt.; and the one cast in 1819 weighs 1600 cwt., the clapper alone weighing 18 cwt. On the cathedral of Paris a bell was placed in 1680, which weighed 340 cwt., and measured 25 feet in circumference. In Vienna a bell was cast, in 1711, of 354 cwt. In Olmütz is one of 358 cwt. The famous bell at Erfurt, in Germany, which is considered to be of the finest bell-metal, having the largest proportion of silver in it, and is baptized *Susanne*, weighs 275 cwt., is more than 24 feet in circumference, and has a clapper of 4 feet, weighing 11 cwt. Great Tom, of Christ Church, Oxford, weighs 17,000 lbs.; of Lincoln, 9894 lbs.; the bell of St. Paul's, London, 8400 lbs.; a bell at Nankin, in China, is said to weigh 50,000 lbs.; and seven at Pekin, 120,000 lbs. each The inscriptions on old bells are curious, and in some cases, have even historical value; and, at this time, when curiosities of all kinds are eagerly sought for, a collection of these inscriptions would not be uninteresting. The different uses of bells have given rise to many poems, some of which are inscribed on the bells themselves. One of the most common is the following:

> Funera plango, fulgura frango, sabbata pango
> Excito lentos, dissipo ventos, paco cruentos.

Perhaps the finest poem which has ever been written on bells is Schiller's poem, *Die Glocke* (The Bell), in which he describes the casting of the bell, and all its uses, in a highly poetical manner. This has been translated into many languages, and lately into Greek and Latin, by a professor at Liege.

Bellows; a machine so formed as to exhale and inhale air by turns, by the enlargement and contraction of its capacity. As soon as men began to make use of fire, the importance of bellows was felt, since the natural bellows, if we may give this name to the lungs, could not be applied to any great extent. The invention of bellows is ascribed to Anacharsis, the Scythian. Probably, this invention, like so many others, took place in different countries, since the want which occasioned it is universal. The first deviation from the ancient, and still common form of the bellows, was made by the Germans about 100 years ago, and the forms at present are very various, as many attempts have been made for the improvement of this highly important machine, which becomes necessary wherever a powerful flame is required in the arts. As mining is carried on extensively in Germany, and great heat is required in smelting the ores, and working the metals, many new kinds of bellows have been invented in that country, of which we only mention that of Mr. Von Baader, in Munich. It consists of an empty box, which moves up and down in another, partially filled with water. Between the bottom of the empty box and surface of the water is a space filled with air, which is driven out by the descent of the enclosed box. Bellows of very great power are generally called *blowing-machines*. One of the largest is that recently erected in England, at the smithery in the king's dock-yard, at Woolwich. It is adequate to the supply of air for forty forge fires, amongst which are several for the forging of anchors, iron knees, and many other heavy pieces of smithery. The common Chinese bellows consist of a box of wood about two feet long, and one foot square, in which a thick, square piece of board, which exactly fits the internal cavity of the box, is pushed backwards and forwards. In the bottom of the box, at each end, there is a small conical or plug valve to admit the air, and valves above to discharge it.

Bellows, *Hydrostatic*, is a machine constructed expressly for the purpose of showing in the most striking manner that the pressure of fluids is as their perpendicular heights, and that a quantity, however small, may be made to support a weight, or another quantity, however large.



This machine is represented in the accompanying figure; it consists of two circular boards, about twenty inches in diameter; these boards are connected by means of strong leather, which entirely surrounds them, and permits them to open and close like a pair of common bellows, with this difference, that they open equally all round, and therefore the boards always remain parallel to one another. The leather, at its junctures, is well secured, and the whole machine is water-tight. In the under board is fixed a pipe communicating with the interior, and reaching to a considerable height above. Through this pipe let some water be poured into the bellows, and the upper board will be observed to rise a little; place a weight of 100 pounds upon it, pour in more water, and it will be found no obstruction to its rising further; increase the weight to 300 pounds, and the pressure of the water in the tube will overbalance the whole; add water, till the leathers are at their utmost extension; the water will then fill in the tube, and the upper board cannot be depressed, nor the water forced out of the small tube, until the pressure upon it is more than that of a column of water, whose diameter is equal to that of the interior of the bellows, and its height equal to that in the tube; by increasing therefore the length of the tube, a most enormous weight might be raised by the pressure of a few ounces of water.

The principle of the hydrostatic bellows has been applied in the invention of a very valuable machine called the *Hydrostatic Press*, which see.

Bend Dexter, in *Heraldry*; is one of the nine ordinaries, and occupies one-third of the escutcheon when charged, and one-fifth when plain; it consists

of two equal lines, drawn diagonally from the dexter chief to the sinister base of the shield. This ordinary has more subdivisions or diminutives than any of the others, viz. bendlet, gortier, and ribbon, none of which diminutives can properly be charged.

Benzoic Acid is obtained by the application of a moderate heat to the balsam of Peru: it rises in vapour, and condenses in slender prisms, which are white and brilliant. It has a peculiar aromatic odour. When heated on burning fuel, it inflames and burns with a clear yellow light. It unites with alkalies and earths, forming salts called *benzoates*, which are unimportant, except the benzoate of iron, which, from its insolubility, affords a convenient means of separating iron from its solutions, so as to ascertain its quantity, and also of obtaining it free from manganese, which forms with the acid a soluble salt.

Benzoin is a solid, fragile, vegetable substance, of a reddish-brown colour. In commerce, two varieties are distinguished, viz. the common and the amygdaloidal; the latter containing whitish tears, of an almond shape, diffused through its substance. It is imported from Sumatra, Siam, and Java, and is found also in South America. Benzoin is obtained from the tree called *styrax benzoin*, and perhaps from some others. On making incisions into the bark, it flows out in the form a balsamic juice, having a pungent taste, and an agreeable odour. The pure balsam consists of two principal substances, viz. a resin, and a peculiar acid termed *benzoic*, which is procured from the mass by sublimation. It is soluble in water. This acid is found, also, as a constituent principle in storax and the balsams of Tolu and Peru: it exists in the urine of cows, camels, and even of young children. It is sometimes found in a crystalline form on the pods of the vanilla. Benzoin is not soluble in water, but is readily dissolved in alcohol, by the aid of a gentle heat. The tincture thus made is used in pharmacy. A small quantity of this tincture, dropped into water, forms a white, milky fluid, which is used in France as a cosmetic, under the name of *lait virginal*. The gum is a principal ingredient of the common court plaster. The acid, as well as the gum, is employed in medicine: they are stimulating, and act more particularly upon the pulmonary system; whence they are used in asthma and chronic catarrh.

Bergamotte; a certain fragrant and cordial essence, extracted from a kind of lemon in Italy; the fruit of a lemon tree ingrafted on a Bergamot pear tree. The liquor is an ætherial oil, very subtile, and of an agreeable smell. Medicinally it operates on the heart, the stomach, and the head.

Berguet, in *Commerce;* a weight of 173 pounds, by which hemp and other goods are sold in Russia.

Beryl; a beautiful sea-green colour, for the use of artists, is prepared under this name. We referred to it under the name of Aqua Marina, from which it is erroneously supposed to be made. It is very costly, and rarely found of a durable quality.

Bessich; a tin coin at Orinus, in value much less than a farthing.

Bevel, or Bevil, in *Architecture;* any angle that is not a right angle or square, or is more or less than 90 degrees; but if it has an angle of 45 degrees, it is called a mitre. Also an instrument resembling a square and the mitre, but having its blade moveable for the proper adjusting of angles for the workmen. It differs from the square and the mitre, the blades of which are fixed at their relative degrees of aperture.

Bezant; round, flat pieces of pure gold, without any impression, supposed to have been the current coin of Byzantium. This coin was probably introduced into coat-armour by the Crusaders. Doctor Henry, in his *History of England*, estimates its value at 9*s*. 4½*d*. sterling. The gold offered by the king of England on the altar, at the feast of the Epiphany and the Purification, is called *bezant*.

Bezel, or Bezil, in *Architecture;* the upper part of the collet of a ring, which encompasses and fastens the stone in it.

Bezoar; a medicinal stone brought from the East and West Indies, which was formerly reckoned a sovereign antidote against poisons. It is found to be a morbid concretion in the stomachs of some animals, which consists partly of bile and partly of resin. The bezoars are distinguished into Oriental bezoar; found in the stomach of an animal of the goat kind in Persia, called pazan. Occidental bezoar, found in quadrupeds of the deer kind. Bezoar hystricus, found in the gall-bladder of the Indian porcupine. Monkey bezoar, found in certain monkeys of Brazil. German bezoar, found in the stomach of the chamois.

Bice, in *Painting;* a pale blue colour, which is prepared from the lapis armenius (smalt), and is inclined to be sandy. Bice requires good and careful grinding, and after ultramarine (which is too expensive for common use), it is one of the best of blues. A green colour formed by mixing the blue with orpiment, bears the same name; as do also certain compositions of indigo and verditer with chalk.

Biceps (bicapital, or double-headed); an epithet for several muscles having two heads, as, biceps cubiti, a muscle of the elbow, the outermost head of which rises from the acetabulum scapulæ. Biceps femoris, which rises from the protuberance of the ischium, on the back part. Its office is to bend the tibia. Biceps humeri, or biceps flexor, rising by one head from the glenoid cavity, by the other from the caracoid process. It acts both as a flexor and a rotator.

Bigot, in *Commerce;* a Venetian liquid measure, containing the fourth part of the amphora, or half the boot.

Bile; a yellowish-green liquid substance, of a bitter taste. Man and many animals have, on the inferior surface of the liver, a peculiar bladder, in which the bile, formed by the liver from the blood, is preserved. It consists of water and several other substances. The water constitutes the greatest part, and keeps the other parts in a state of solution. The remaining ingredients are a yellow, very bitter, fusible resin, which contributes most to the taste of the bile; a small portion of natron; some mineral alkaline salts; some oxide of iron; a small quantity of a yellowish substance, which is only partly dissolved in the natron; and a considerable portion of albumen. Thenard and Berzelius have done much to determine the ingredients of the bile. Its principal use seems to be, to separate the excrement from the chyle, after both have been formed, and to produce evacuations from the body. It is probable that these substances would remain mixed together, and they would, perhaps, even be partly absorbed together, were it not for the bile, which seems to combine with the excrement, and, by this combination, to facilitate its separation from the chyle, and thus to prevent its

absorption. Fourcroy supposes that the bile, as soon as it is mixed with the contents of the intestinal canal, suffers a decomposition; that its alkali and saline ingredients combine with the chyle, and render it more liquid, while its albumen and resin combine with the excrementitious matters, and gradually render them less fluid. From the late experiments of Berzelius, it cannot be doubted that the constituents of the bile are to be found in the excrementitious matter; so that the ingenious theory of Fourcroy is so far probable. The bile also stimulates the intestinal canal, and causes it to evacuate its contents sooner than it otherwise would do; for when there is a deficiency of bile, the body is constantly costive. Biliary calculi, or gall-stones, are sometimes found in the gall-bladders of men and animals. They are more rarely met with in the substance and body of the liver. Those that are found in the human subject consist, principally, of that peculiar substance, called, by Fourcroy, *adipocire*. They are of a white, grayish-brown, or black colour. The calculi found in the gall-bladders of quadrupeds have been thought to consist almost entirely of inspissated bile; but, though much less complicated than the corresponding concretions in the human subject, they must contain something more than the inspissated fluid, since they are insoluble, both in alcohol and water. (See JAUNDICE, and FEVER, BILIOUS.)

BILIARIS CALCULUS, in *Medicine*; the professional term for the gall-stone.

BILL, in *Agriculture*; an edged tool of the axe kind, with a hooked point, fitted to a handle, and used to lop boughs off trees, &c. When short, it is called a "hand-bill;" when long, a "hedge-bill."

BILLIARDS; a very interesting game, contributing also to health by affording the body moderate exercise. It was originally invented in France, whence it was introduced into the different nations of Europe. It is generally practised in almost all civilized countries, and affords a very agreeable recreation and amusement. The rules for the different games of billiards are too numerous to be given here. They are also generally found in billiard rooms. We therefore omit them, although we usually give the rules of games, in order to furnish a means of reference in doubtful cases. They may be found in *Hoyle's Games*.

BINNACLE, or BITTACLE; a case or box which contains the compass for steering a ship, and lights to show the compass at night. In ships steered by a wheel, it is common to have two binnacles, or a double binnacle, for the convenience of the steersman, on either side of the wheel; but, in this case, the compasses affect each other's direction, and thus render the ship's course uncertain.

BINOMIAL; an algebraic expression consisting of two terms; thus, $x+a$, $x-a$ are binomials.

BINOMIAL THEOREM, the general algebraical formula for the developement of any power of a binomial, or its expression, in a series consisting of single terms.

A *power* of a number is the phrase employed in mathematical language to denote the result of the multiplication of that number by itself as many times as are indicated by the degree of that power; the obvious mode, therefore, of *raising a number to any power*, is to multiply it successively by itself the requisite number of times. If we proceed in this manner, we may obtain the following powers of the binomial $x + a$.

$$(x+a)^2 = x^2+2ax=a^2,$$
$$(x+a)^3 = x^3+3ax^2+3a^2x+a^3,$$
$$(x+a)^4 = x^4+4xx^3+6a^2x^2+4a^3x+a^4,$$
$$(x+a)^5 = x^5+5ax^4+10a^2x^3+10a^3x^2+5a^4x+x^5.$$

This table might be continued to an indefinite extent; the examples we have given are, however, sufficient for our purpose. We see that the multiplication of $x+a$ by itself once, produces $x^2+2ax+x^2$; and as x and a represent no particular numbers, this product, which is the square of their sum, is a general expression for the square of the sum of any two numbers. For the same reason, the multiplication of this binomial by itself two, three, and four times respectively, or the performance of the operations indicated by $(x+a)^3$, $(x+a)^4$ and $(x+a)^5$, furnishes us with general expressions for the third, fourth, and fifth powers of the sum of any two numbers. But each of these expressions is, we perceive, different; the *law of composition*, as it is termed, of one power, is peculiar to that power, and applies to no other. The square of the sum of two numbers is not composed of *the cube of the first, plus three times the product of the second by the square of the first, plus three times the product of the first by the square of the second, plus the cube of the second;* nor is their cube made up of *the square of the first, plus twice the product of the first and second, plus the square of the second.* Unless, therefore, we can discover some general principle which regulates the formation of all powers of a binomial, we must necessarily have a separate expression for each power; and as the number of powers is of course indefinite, so must also be that of the expressions. A formula has, however, been invented, which is universally applicable to all powers of a binomial, and which embraces the law of composition of every one of them; this formula is termed the *Binomial Theorem*, and its demonstration is the subject of the present article.

It will, indeed, at once be seen that in each of the expressions which we have already obtained, the exponents of the letters of the different terms obey the same simple law; but it is not so easy to perceive that one common principle regulates their numerical coefficients. This was, however, ascertained by Newton, who discovered the existence of a certain relation between the coefficient of any term, and the coefficient and exponent of the one preceding, which enabled him at once to raise a binomial to a power of any given degree, without being compelled to ascend to it gradually through all the inferior degrees, or even to have recourse to the general formula. On the subject of the reasonings by which he was led to the discovery of this law, Newton has left us no information; he appears, indeed, from his own account,* to have sought it empirically, and to have formed it from an investigation of particular cases; but it has since been rigidly established, as a universal law, in a variety of ways. Of the different demonstrations which exist, the most elementary is that founded on the theory of combinations; therefore, in the following investigation, we necessarily presume the reader to be acquainted with that theory, for an explanation of which we refer to the article PERMUTATIONS and COMBINATIONS.

It may be advisable to recapitulate some of the results which are there obtained. The number of

* In a letter dated October 24, 1676, which he addressed to Oldenburg, one of the secretaries of the Royal Society, to be transmitted by him to Leibnitz. It is that numbered LV. in *Collin's Commercium Epistolicum.*

combinations of which m letters are susceptible, taken two at a time, is expressed by $\frac{m.(m-1)}{1.\ 2}$; taken three at a time, by $\frac{m.(m-1).\ (m-2)}{1.\ 2.\ 3.}$; four at a time, by $\frac{m.\ (m-1.\ (m-2).\ (m-3)}{1.\ 2.\ 3.\ 4}$, and generally, when taken n at a time, by

$$\frac{m.\ m-1.\ m-2\ \ldots\ldots\ldots\ m-n+1}{1.\ 2.\ 3.\ \ldots\ldots\ n}$$

Or, if $\frac{P}{Q}$ represent the number of combinations of m letters taken $n-1$ at a time.

$$\frac{P\ (m-n+1)}{Q\ n}$$

will express those of the same number of letters taken n at a time. These formulæ should be well understood and remembered, as they are of essential importance in the investigation to which we now proceed.

We remarked, that it was not easy to recognise any common principle which regulated the formation of the numerical coefficients of the terms of all the different powers of the binomial $x+a$. If we reflect for a moment on the nature of the process of multiplication, we shall perceive that these coefficients arise from the reduction that takes place between the like terms which must necessarily occur in a product resulting from the multiplication of factors which are all equal. This will at once be rendered apparent by performing, at full length, some one of the operations by which we have obtained those powers,—that of the square or second power, for instance:

$$\begin{array}{l} x+a \\ x+a \\ \hline x^2+ax+a^2 \\ \hline x^2+ax+ax+a^2=x^2+2\,ax+a^2. \end{array}$$

Here, in consequence of the similarity of the two factors $(x+a)$, $(x+a)$, the term ax occurs twice in their product, once as the result of the multiplication of a in the multiplicand by x in the multiplier, and again, as the result of multiplication of x in the multiplicand by a in the multiplier. The simplification of the product produces the numerical coefficient 2. But let us alter the second term of one of the factors, and for a substitute b; there will then be no two terms in both which are similar, therefore we shall have no like terms, and consequently no numerical coefficient in their product. We have

$$(x+a)\ (x+b)=x^2+ax+bx+ab,$$

or, collecting all the terms containing the same power of x into the same column, the product becomes,

$$\begin{array}{l|l} x^2+a & x+ab \\ \quad\ +b & \end{array}$$

This dissimilarity of the factors renders the law of composition of the product of two binomials more apparent than in the disguised form in which that product is obtained, when those factors are alike; hence, our investigation of this law will be greatly facilitated by observing its character when it occurs in that more undisguised state. To each of the binomial factors then, which we employ, let us give a different second term; that is to say, for $(x+a)$ $(x+a)$ or $(x+a)^2$, let us substitute $(x+a)\ (x+b)$; for $(x+a)^3$, $(x+a)\ (x+b)\ (x+c)$; for $(x+a)^4$, $(x+a)\ (x+b)\ (x+c)\ (x+d)$, and so on. We shall thus obtain the following results, according to the ordinary rules of algebraical multiplication:

$$\begin{array}{ll} & x+a \\ & x+b \\ \hline (1.)\ .. & \begin{array}{l|l} x^2+a & x+ab \\ \quad\ +b & \end{array} \\ & x+c \\ \hline (2.)\ .. & \begin{array}{l|l|l} x^3+a & x^2+ab & x+abc \\ \quad\ +b & \quad\ +ac & \\ \quad\ +c & \quad\ +bc & \end{array} \\ & x+d \\ \hline (3.)\ .. & \begin{array}{l|l|l|l} x^4+a & x^3+ab & x^2+abc & x+abcd \\ \quad\ +b & \quad\ +ac & \quad\ +abd & \\ \quad\ +c & \quad\ +ad & \quad\ +acd & \\ \quad\ +d & \quad\ +bc & \quad\ +bcd & \\ & \quad\ +bd & & \\ & \quad\ +cd & & \end{array} \end{array}$$

The expressions (1), (2), (3), are the products respectively of two, three, and four binomials; for convenience, we have arranged all the terms of each, which contain the same power of x in the same column, writing that power itself only once. This method is much more convenient than that of disposing those terms in the same horizontal line, for instance, than the arrangement of $abx+acx+bcx$, in the form of $(ab+ac+bc)\ x$. In either case, the expression is considered as a single term, in this particular example, made up of the factors $(ab+ac+bc)$ and x; and $ab+ac+bc$ is called the coefficient of x in that term. If we now examine these products, we shall observe the following law to regulate the formation of each:

1°. The exponent of x in the first term is equal to the number of binomials multiplied; in the second, it is one less than that number, and each succeeding term it decreases by unity, until in the last it becomes equal to zero. It follows from this observation, that the number of terms (in the extended sense of the word) in each product is greater by one than the number of binomials, whose multiplication gives that product.

2°. The coefficient of x in the first term, or that containing the highest power of that letter, is unity; in the second, whose exponent is one less than that of the first, it is equal to the sum of the second terms of all the binomial factors; in the third, whose exponent is two less than that of the first, to the sum of the different products obtained by the multiplication of every two of those second terms; in the fourth, whose exponent is three less than of the first, to the sum of all the products of every three of them, and so on.

3°. The last term is equal to the product of all the second terms of the binomials.

We have thus found a certain law to regulate the formation of the respective products of two, three, and four binomials. Were we to examine those resulting from the multiplication of five, six, seven, or eight, and the binomials, we should find them all to obey a law precisely similar. Hence, we might from analogy conclude, that the same would be the case with any number of binomials, and that the law in question was general. But analogy is not enough; we must have rigid proof before we can be warranted in drawing such a conclusion. This we may obtain in the following manner:

Suppose it to be the case, that this law does hold good for the product of a certain number which we will call m, of binomials; let us see whether it be also true, when the number is one greater, or, $m+1$; in other words, when an additional factor is introduced. The successive powers of x will be expressed by

$$x^m,\ x^{m-1},\ x^{m-2},\ x^{m-3},\ \&c.,$$

and the coefficients of these, beginning with x^{m-1}, let us represent respectively by

$$A,\ B,\ C,\ \&c.,$$

A being by supposition equal to the sum of the second terms of the m binomials; B, to the sum of the different products of every two of those terms; C, to the sum of the products of every three of them, and so on. Then Ax^{m-1} will be the seccond term of the product, or that which has one term before it; Bx^{m-2}, the third, or that having two terms before it; Cx^{m-3}, the fourth, which has three terms before it, and so on. As m is undetermined, so must be the number of the terms in the product; we may, however, give a general expression for every one of those terms, by calling it the n^{th} term. This term will, if our rule be, as we suppose, true, have $n-1$ other terms before it. The exponent of x which is supposed gradually to decrease from m in the first term, to zero in the last, will be $m-(n-1)$, or, more simply, $m-n+1$; and the coefficient of that letter will be the sum of the products resulting from the multiplication of every $(n-1)$ of the second terms of the m binomials. Let us call this coefficient M; then the n^{th} term will be represented by Mx^{m-n+1}. Similarly, the next, or $(n+1)^{th}$ term, being that which has n terms before it, will be represented by Nx^{m-n}, N being supposed to stand for the sum of the products of every n of the second terms of the m binomials. Finally, if we designate the last term, or that consisting of the product of all those second terms by U, we have the following expression for the product of m binomial factors.

$$x^m + Ax^{m-1} + Bx^{m-2} + Cx^{m-3} \ldots\ldots Mx^{m-n+1} + Nx^{m-n} \ldots\ldots + U. \qquad \text{(I.)}$$

This product we suppose to obey the laws which we have observed to obtain in the particular cases we examined; and our sole object now is, to see whether, such being the case, those same laws will hold good when the number of factors is increased by one, or made to become $m+1$. Let $x+l$ be the new factor introduced; multiplying the product of m binomials by it, we have for that of $m+1$ binomials

$$\begin{array}{l|l|l|l|l} x^{m+1} + A & x^m + B & x^{m-1} + C & x^{m-2} \ldots\ldots + N & x^{m-n+1} \\ \qquad + l & \quad + lA & \quad + lB & \qquad\qquad + lM & \qquad \ldots\ldots + lU. \end{array}$$

In the first place, the law of the exponents holds good. This is also the case with that of the coefficients. To ascertain this point, however, we must examine them each separately.

1°. The coefficient of the first term is *unity*.

2°. By the supposition, A represents the sum of the second terms of the m binomials, and l is itself the second term of the new binomial introduced; therefore, $A+l$ is *the sum of the second terms* of the $m+1$ binomials. Hence, the coefficient of x in the second term obeys the law laid down.

3°. By the hypothesis, B is equal to the sum of all the products of every two of the second terms of the m binomials; and as A represents the sum of those terms, lA is the sum of the products of each of them by the new factor l; therefore, $B+lA$ expresses *the sum of the products of every two of the second terms* of the $m+1$ binomials. Or the law is true for the coefficient of x in the third term.

4°. C is the sum of the products of every three of the second terms of the m binomials; B is the sum of the products of every two of those terms, whence lB expresses the sum of the products (each consisting of three second terms) resulting from the multiplication of every one of the products (each of two second terms) composing B by the new second term l; therefore, $C+lB$ must represent *the sum of the products of every three of the second terms* of the $m+1$ binomials. Hence, the law holds good for the coefficient of x in the fourth term.

The same would be found to be the case with the coefficients of all the other terms, as we can easily see by referring to that which is a general representative for every term, namely, the $(n+1)^{th}$ term, in which the exponent of x is denoted by $(m+1)-n$, or $m-n+1$, and its coefficient by $N+lM$. By the hypothesis, N is the sum of all the products of every n of the second terms of the m binomials; and M represents the sum of all the products of every $(n-1)$ of those terms; whence lM represents the sum of the products obtained by the multiplication of each of the products composing M by l; therefore, $N+lM$ expresses *the sum of all the products of every n of the second terms* of the $m+1$ binomials, for the multiplication of each of the products of $n-1$ second terms by the additional second term l, renders that product a product of n second terms.

Finally, U being by supposition equal to the product of all the second terms of the m binomials, $U\times l$, or lU, is the product of all the second terms of the $m+1$ binomials: hence, the last term also follows the law laid down.

We have thus proved that if the law of composition which we deduced be true for the product of m binomials, it is equally so for that of $m+1$ binomials; in other words, that if it holds good for the product of any number of binomials, it holds good for that of a number one greater. But we know that it is true for the product of four binomials; it is therefore true for that of $4+1$, or 5; and hence, for that of $5+1$ or 6, $6+1$ or 7, and so on, counting upwards for that of any number of binomials whatsoever. It is therefore general.

This method of demonstration, which is a species of induction, may perhaps not at first appear quite so rigid as others which are employed in algebra; a little reflection will, however, render it perfectly satisfactory. It is one of the highest importance and of frequent application: we may mention another instance of its occurrence, which will be found in the article DIVISION, where it is resorted to for the purpose of proving the divisibility of a^m-b^m by $a-b$.

Since, then, we have established generally the law of composition of the product of any number of binomials, the expression (I), which is formed according to that law, will correctly represent the product of m binomials, $x+a$, $x+b$, $x+c$, $x+d$, &c., the

values of A, B, C; M, N; U remaining as before. Let us suppose now that all the second terms, a, b, c, d, &c. of the m binomials are made equal to one another, that $a = b = c = d$; the product $(x + a)$, $(x + b)$, $(x + c)$, $(x + d)$, &c. becomes in that case the factor $x + a$ repeated m times, or $(x + a)^m$. The changes in the developement of this product, or in the expression (I) itself are more extensive. 1°. The coefficient of the second term, or $a + b + c + d$, &c., becomes $a + a + a + a$, &c., or a repeated as many times as there are letters a, b, c, &c., and is therefore equal to ma; the term itself thus becomes max^{m-1}. 2°. The coefficient of the third term, or $ab + ac + ad$, &c., becomes $a^2 + a^2 + a^2$, &c., or a^2 repeated as many times as there are products ab, ac, ad, &c.; but the number of these products is equal to the number of times that a different two of the m letters a, b, c, d, &c. can be taken; in other words, to the number of combinations of m things taken two at a time; this, as we previously observed, is expressed by $m.\frac{m-1}{2}$, therefore the co-efficient of this term is $m.\frac{m-1}{2}a^2$, and the term itself $m.\frac{m-1}{2}a^2x^{m-2}$. 3°. The co-efficient of the fourth term becomes in a similar manner, a^3 repeated as often as there are combinations of m things taken three at a time, or $m\frac{m-1}{2}.\ \frac{m-2}{3}a^3$; and $m\ \frac{m-1}{2}.\ \frac{m-2}{3}a^3x^{m-3}$ represents the term itself.

The coefficient of the $(n + 1)^{\text{th}}$ term Nx^{m-n}, or that having n terms preceding it, may be ascertained in the same manner. For N represents the sum of all the products of every n of the second terms of the m binomials; but as we now suppose all these second terms to become equal to one another, the sum of the products of every n of them becomes the product of a single n of them, repeated as many times as a different n of them can be taken; in other words as there are combinations of m things taken n at a time. Therefore, N, or the coefficient of the $(n + 1)^{\text{th}}$ term, becomes

$$m\frac{m-1}{2}.\ \frac{m-2}{3}\ \cdots\ \frac{m-n+1}{n}a^n.$$

This expresssion, as we have already observed in a preceding part of this article, may be put under the form of

$$\frac{P(m-n+1)}{Qn}a^n$$

$\frac{P}{Q}$ representing the number of combinations of m things taken $n-1$ at a time; therefore, the $(n + 1)^{\text{th}}$ term will be expressed by

$$\frac{P(m-n+1)}{Qn}a^nx^{m-n}.$$

Finally, the last term of the expression (I), or $abcd$, &c., becomes the product of m equal factors, and is represented therefore by a^m. Collecting together all those terms, we obtain for the product of $x + a$ multiplied m times, or $(x + a)^m$, the following formula:

$$x^m + max^{m-1} + m\frac{m-1}{2}a^2x^{m-2} + m\frac{m-1}{2}.\frac{m-2}{3}a^3x^{m-3}\ \cdots\ + \frac{P(m-n+1)}{Qn}a^nx^{m-n}\ \cdots\ a^m.$$

This formula, then, is the Binomial Theorem; it is the *developement* or *expansion* of $(x + a)^m$, and is a general expression in single terms for any power of a binomial. It enables us to form that power without being obliged to have recourse to the ordinary method of successive multiplication. For instance, suppose that we wished to ascertain the sixth power of $2y + 3z^2$; instead of multiplying that binomial by itself five times, we need only substitute in the above formula $2y$ for x, wherever that letter occurs, $3z^2$ for a, and the number 6 for m; filling up the blanks, if any (which we were obliged to leave so long as m was undetermined), according to the general law of composition, and simplifying by the performance, as far as possible, of the operations indicated, the result will be the power required. We omit the process here; it will form an useful exercise to the student, who may easily verify his result, by comparing it with that obtained according to the ordinary rules of multiplication.

If we now slightly examine this formula, we shall perceive that the law which it obeys, is in every respect of such a simple character, as to be easily remembered; so, that by applying it directly in the formation of a power of a binomial, we may dispense with the intervention of the formula itself. We observe, then,

First, that the number of terms which it contains, is $m + 1$, or greater by unity than that of the binomials multiplied.

Secondly, that with regard to the exponents of the letters x and a,

The exponent of x continually decreases from m in the first term, to zero in the last.

The exponent of a continually increases from zero in the first term, to m in the last.*

Thirdly, that with respect to the coefficients,

The coefficient of the letters ax in the first term is unity; and the coefficient of the same letters in every other term, is successively formed by multiplying the coefficient of those letters in the preceding term by the exponent of x in that term, and dividing by the number of terms which precede the one we are considering.

The first two observations have been already established; the third, which was first remarked by Newton, is of very great practical utility, as it enables us to form at once the expansion of any power, without recurring to the general formula.

The coefficients to which it refers, are evidently entirely numerical, supposing of course, m to have a particular value assigned to it, or to become determined. Of its truth we may easily satisfy ourselves. The coefficient of x^m (or $a^0 x^m$) in the first term is 1, and the exponent of x in that term, m; therefore $\frac{1 \times m}{1}$ or m, is the coefficient of $a\,x^{m-1}$ in the second term. Similarly, $m\ \frac{m-1}{2}$ is the coefficient of $a^2\,x^{m-2}$ in the third term; and $m\ \frac{m-1}{2}.\ \frac{m-2}{3}$ that of $a^3\ x^{m-3}$ in the fourth. The composition of the coefficient of the $(n+1)^{\text{th}}$ term $\frac{P(m-n+1)}{Q\,n}a^n\ x^{m-n}$

* This would give $a^0\ x^m$ for the literal portion of the first term, and $x^0\ a^m$ for that of the last, or as $a^0 = 1$ and $x^0 = 1$, (see Art. ALGEBRA, under the head of *Division*) $1x^m$ or x^m for the first, and $1a^m$ or a^m for the last.

also obeys this law; for the literal portion of the term preceding this, or of the n^{th} term, must be $a^{n-1}\,x^{m-n+1}$, the exponent of a being one less, and that of x one greater than in the $(n+1)^{th}$; and the coefficient of these powers in the n^{th} term must, according to the law of composition we have established, be the number of combinations of m things taken $n-1$ at a time; but this is precisely what $\frac{P}{Q}$ represents, and what we substituted it for; multiplying then the coefficient of the n^{th} term, or $\frac{P}{Q}$ by the exponent of x in that term, or $m-n+1$, and dividing the product by n, the number of terms preceding the $(n+1)^{th}$, or the term we are considering, the result $\frac{P\,(m-n+1)}{Q\,n}$ should be the coefficient of that $(n+1)^{th}$ term; and such as we see is the case. This $(n+1)^{t}$ term $\frac{P\,(m-n+1)\;a^n\,x^{m-n}}{Q\,n}$ is called the *general* term of the devolopement, because by successively giving n every value between 0 and m, it represents each particular term, and whatever we can prove to be true for it must of necessity be true for every term in the developement.

Let us now take as an example the devolopement of $(x+a)^5$.

The first term being $1a^{\circ}\,x^5$ or $1x^5$,

The second becomes $\frac{5\times1}{1}\,a^1x^4$ or $5ax^4$,

The third . . . . $\frac{5\times4}{2}\,a^2x^3$ or $10a^2x^3$,

The fourth . . . $\frac{10\times3}{3}\,a^3x^2$ or $10a^3x^2$,

The fifth . . . . $\frac{10\times2}{4}\,a^4x^1$ or $5a^4x$,

The sixth . . . $\frac{5\times1}{5}\,a^5x^{\circ}$ or a^5.

Here we must stop; we have come to the term in which the exponent of x is zero, and that of a is m, and this according to the law must be the last term. Besides, the expression here ceases for another reason; to continue, it would be necessary to multiply by the exponent of x, but this exponent is zero.

It is evident, that when the exponent of the power to which a binomial is to be raised is an odd number, the developement of that power will contain an even number of terms; and *vice versa*. For the number of terms being always $m+1$, if m be odd, $m+1$ must be even, and if even, $m+1$ must be odd. Thus in the above example, the exponent of the power is 5 in an odd number, and the number of terms is 6, or an even one. We also observe, if we examine the developement of that power, that two terms which are equal distances from its two extremities have always the same coefficient; this is the case with the second and fifth, and with the third and fourth. The reason is this. the coefficient of the third term is equal to the number of combinations of m or 5 things, taken two at a time, or is $\frac{5\times4}{2}$, and the co-efficient of the fourth term to that of the same number of things taken three at a time, or to $\frac{5\times4\times3}{2\times3}$; striking out the common factor 3, the latter becomes $\frac{5\times4}{2}$, or the same as the former. This may be proved generally thus: the coefficient of $a^n\,x^{m-n}$, is according to the general law of composition, equal to the number of combinations of m things taken n at a time, and the coefficient of $a^{m-n}\,x^n$, to that of the same number of things taken $m-n$ at a time; but it is proved in the investigation of the theory of combinations, that these two numbers of combinations are equal, therefore the coefficients of $a^n\,x^{m-n}$ and $a^{m-n}\,x^n$ are equal. Now the term of the developement in which $a^n\,x^{m-n}$ occurs has n terms preceding it; this we can tell from either the exponent of a or x, and the term of $a^{m-n}\,x^n$ has for a similar reason n terms following it, or the former is at the same distance from the beginning that the latter is from the end of the developement; in other words, they are equi-distant from the two extremities. Hence, in the developement of any power of a binomial, coefficients of terms equi-distant from the two extremities, are equal.

Suppose now that we require the developement of $(x-a)^5$, or the fifth power of a binomial whose terms are connected by the negative sign. Proceeding according to the general law laid down,

$$(x-a)^5 = x^5 - 5ax^4 + 10\,a^2x^3 - 10a^3\,x^2 + 5a^4x - a^5$$

Comparing this with the developement of $(x+a)^5$ given above, we find that it differs from that only in having every alternate term, commencing with the second, negative. The reason is evident; every odd power of a negative quantity must be negative, and every even one positive. Thus, $-a\times-a$ is according to the rule of multiplication for negative quantities (see Art. NEGATIVE SIGN), a^2, or the second power of $-a$ is positive; $a^2\times-a$ is $-a^3$, or the third power of $-a$ is negative; and proceeding in this way, we find the different powers of $-a$ in succession to be alternately negative and positive, the odd powers being the former, and the even powers the latter. In the developement then of $(a-x)^5$ the second term must necessarily be negative, for it is composed of

$$5\times(-a)\times x^4 \text{ or } -5\,a\,x^4.$$

The third term contains an even or positive power of a, and is therefore positive; but the fourth contains an odd power, and is therefore negative, and so on. We can therefore easily see the reason why the developement of $(x-a)^m$ should by the substitution of $-a$ for a in the general formula, become

$$x^m - max^{m-1} + m.\frac{m-1}{2}\;a^2\,x^{m-2} - m.\frac{m-1}{2}.\frac{m-2}{3}\;a^3\,x^{m-3}.$$

In other words, why the terms of the developement of any power of a binomial whose second term is negative, should be alternately positive and negative.

In the preceding investigation $(x+a)^m$ stands for $(x+a)\,(x+a)\,(x+a)\,(x+a)$ . . . . &c., or the factor $(x+a)$ repeated m times; consequently m must be a whole positive number, and the formula therefore which we have obtained for the developement of $(x+a)^m$, is therefore only applicable when m is a whole positive number. It has, however, been extended by mathematicians to all cases, whether m be whole or fractional, positive or negative; and the demonstration of this property will be given under the respective heads of FRACTIONAL and NEGATIVE EXPONENTS.

Bipartient, in *Arithmetic*, is a number that divides another into two equal parts without a remainder. Thus 2 is a bipartient to 4, &c.

Biquadrate, in *Algebra*; an obsolete term for the square of the square; in other words, for the fourth power of any given quantity; thus, 16 would be the biquadrate of 2, for $2 \times 2 \times 2 \times 2 = 16$.

Biquadrate Root; the root of a biquadratic power; thus, 2 is the biquadrate root of 16.

Biquadratic Equation; an equation of the fourth degree, or which contains the fourth power of the unknown quantity, as $x^4 + ax^3 + bx^2 + cx + d = 0$.

Bird-Bolt, in *Heraldry*; a small arrow with a blunt head, and often represented in armory, with two, and sometimes three heads rounded; but in that case the number of heads must be noticed.

Biremis; an ancient ship, with two rows of seats for the rowers. A galley.

Bis, in *Music*, in a composition, signifies that the bars included within the same curve are to be sung or played twice successively.

Bismia; an epithet for piano-forte pieces, in which both hands are alternately employed upon the same melody.

Bismuth is a metal called, by artists, *tin glass*, a name obviously derived from the French *étain de glace*. It is found both pure and mineralized by sulphur, oxygen, and arsenic. Native bismuth occurs in the veins of primitive mountains, and is accompanied by ores of lead, silver, and sometimes of cobalt and nickel. It exists in reticulated, lamellar, or amorphous masses; is soft, and of a white colour, occasionally tinged with red. Specific gravity, 9. It is found in many countries,—in France, England, Sweden, Bohemia, and the United States; but its chief locality is at Schneeberg, in Saxony, from whence the supply of bismuth, in commerce, is principally derived. To procure the metal, the ore requires merely to be reduced to convenient fragments, and heated in furnaces, when the bismuth separates from the earthy matter in which it is engaged, and flows out into cast-iron moulds prepared for its reception. Bismuth, when pure, has a reddish-white colour, is harder than lead, and is easily broken under the hammer, by which it may even be reduced to powder. It melts at 470° or 480°, and crystallizes, on cooling, with great regularity, in the form of cubes. When kept in a state of fusion, at a moderate heat, it is covered with an oxide of a greenish-gray or brown colour; at a higher temperature, it enters into a feeble combustion, forming a yellow powder, called *flowers of bismuth*. It combines, by fusion, with a great number of metals, communicating to them brittleness and fusibility. The mixture discovered by Newton, and produced by melting together 8 oz. bismuth, 5 oz. lead, and 3 oz. tin, fuses at 202°. From it are made toy spoons, which melt on being employed to stir very hot tea. A still more fusible compound was invented by Mr. Dalton, composed of 3 parts tin, 5 lead, and 10½ bismuth, which melts at 197°. The addition of a little mercury renders it even more fusible, and fits it to be used as a coating to the inside of glass globes. An alloy of equal parts of tin and bismuth melts at 280°; a less proportion of bismuth adds to the hardness of tin, and hence its use in the formation of pewter. Equal parts of tin, bismuth, and mercury, form the *mosaic gold*, used for various ornamental purposes. One part of bismuth, with 5 of lead, and 3 of tin, forms *plumbers' solder*, a compound of great importance in the arts. Bismuth is also used by letter-founders in their best type-metal, to obtain a sharp and clear face for their letters. Bismuth combines with sulphur, and forms a bluish-gray sulphuret, having a metallic lustre. The same compound is found native in small quantity, and is called, in mineralogy, *bismuth glance*. Nitric acid dissolves bismuth with great readiness. The solution is decomposed on the addition of water, and a white substance, called *magestens of bismuth*, is precipitated, which consists of a hydrated oxide, united to a small proportion of nitric acid. This precipitation, by the addition of water, being a peculiarity of bismuth, serves as a very excellent test of this metal. The magestens of bismuth, from its whiteness, is sometimes employed to improve the complexion, as well as the *pearl powder*, a similar preparation, differing only by the mixture of a little muriatic acid with the nitric acid in effecting the solution of the bismuth. The liberal use of either, however, is highly prejudicial to the skin. They are, besides, liable to be turned black by the vapours evolved from nearly all putrefying substances. The chloride of bismuth, formerly termed *butter of bismuth*, is formed by pouring bismuth, in fine powder, into chlorine gas, or by depriving the muriate of bismuth of its water of crystallization by heat.

Bisti; a species of Persian money, valued at sixteen or eighteen French deniers.

Bistoury, in *Surgery*; a small knife of various forms, according to the purpose for which it is to be used.

Bistre, or **Bister**, in *Painting*; a colour made from the soot of dry wood, of which beech is the best, boiled half an hour in water, of the proportion of a gallon to two pounds of soot; after it has settled, the water is poured from it, and when evaporated to dryness, and made into cakes with gum-water, it is good bistre. Bistre is much used by architects and painters in washing their drawings and sketches. The King of England has a considerable number of fine drawings in bistre by the old masters; and there are also a great quantity of them in the salle d'Apollon, in the Louvre, at Paris.

Bit; a boring instrument, so constructed as to be taken out of the handle, which is called the stock, by means of a spring. Bits are of different kinds, as shell-bits, for boring wood; centre-bits, which form a cylindrical excavation, by turning on an axis or centre; countersink-bits, for widening the upper part of a hole, &c.

Bitumen; the name of a species in *Mineralogy*, the individuals composing which have acquired several distinct names, from their diversity in appearance. This depends chiefly upon their state of aggregation, which forms an uninterrupted series from the perfectly fluid to the solid condition. *Naphtha*, the most fluid variety, is nearly colourless, or of a yellowish tinge, transparent, and emits a peculiar odour. It swims on water, its specific gravity being from 0.71 to 0.84. It burns with a bluish-white flame and thick smoke, and leaves no residue. It consists of carbon, 82.20, and hydrogen, 14.80; and being the only fluid destitute of oxygen, it is used to preserve those new metals in, which were discovered by Sir Humphry Davy. It is found in Persia, in the peninsula of Apcheron, upon the western shore of the Caspian sea, where it rises through a marly

soil in the form of vapour, and being made to flow through earthern tubes, is inflamed for the purpose of assisting in the preparation of food. It is collected by sinking pits several yards in depth, into which the naphtha flows. It is burned in lamps, by the Persians, instead of oil. Near the village of Amiano, in the state of Parma, there exists a spring which yields this substance in sufficient quantity to illuminate the city of Genoa, for which purpose it is employed. With certain vegetable oils, naphtha is said to form a good varnish. The variety *petroleum* is much thicker than naphtha, resembling in consistence common tar. It has a strong, disagreeable odour, and a blackish or reddish-brown colour. During combustion, it emits a thick, black smoke, and leaves a little residue in the form of a black coal. It is more abundant than the first-mentioned variety, from which it does not appear to differ, except in being more inspissated. It occurs, oozing out of rocks, in the vicinity of beds of coal, or floating upon the surface of springs. In the Birman empire, near Rainanghong, is a hill containing coal, into which 520 pits have been sunk for the collection of petroleum; and the annual product of this mine is 400,000 hogsheads. It is used by the inhabitants of that country as a lamp-oil, and when mingled with earth or ashes, as fuel. In the United States, it is found abundantly in Kentucky, Ohio, and New York, where it is known under the name of *Seneca* or *Genese oil*. It is used as a substitute for tar, and as an external application for the remedy of rheumatism and chilblains. *Maltha* is a bitumen, still less fluid than petroleum, from which it differs in no other respect. Its principal locality is at Puy de la Pège, in France, where it renders the soil so viscous, that it adheres strongly to the foot of the traveller. It is also found in Persia, and in the Hartz. It is employed, like tar and pitch, on cables, and in caulking vessels: it is used, as well as the petroleum, to protect iron from rusting, and sometimes forms an ingredient in black sealing-wax. *Elastic bitumen* yields easily to pressure, is flexible and elastic. It emits a strong, bituminous odour, and is about the weight of water. On exposure to the air, it becomes hard, and loses its elasticity. It takes up the traces of crayons in the same manner as the caoutchouc, or Indian rubber, whence it has obtained the name of the *mineral caoutchouc*. It has hitherto been found only in the lead mines of Derbyshire. *Compact bitumen*, or *asphaltum*, is of a shining black colour, solid and brittle, with a conchoidal fracture. Its specific gravity is from 1 to 1.6. Like the former varieties, it burns freely, and leaves but little residue. It is found in Judea, in the Palatinate, in France, in Switzerland, and in large deposits in sandstone in Albania; but no where so largely as in the island of Trinidad, where it forms a lake three miles in circumference, and of a thickness unknown. A gentle heat renders it ductile, and when mixed with grease or common pitch, it is used for painting the bottoms of ships, and is supposed to protect them from the teredo of the West Indian seas. The ancients employed bitumen in the construction of their buildings. The bricks of which the walls of Babylon were built were, according to historians, cemented with hot bitumen, which imparted to them great solidity.

Biventer; an epithet for a muscle that has two bellies, as the biventer cervicis, a muscle of the lower jaw, &c.

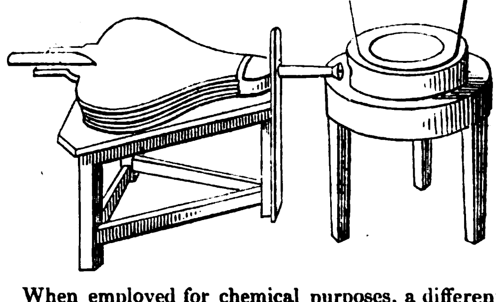
Bivouack (from the German *biwacht*); the name given to the modern system, by which the soldiers in service lie in the open air, without tents, in opposition to the old system of camps and cantonments. They remain dressed, in order to be ready, at a moment's warning, to take their places in order of battle. Tents being laid aside, on the continent of Europe, for the sake of diminishing the baggage of an army, large masses of troops are always obliged to bivouack, even if they are not near the enemy. The soldier, however, is permitted to build himself a hut of straw or branches, if circumstances allow it. Frequent bivouacking is very injurious to the health, and is also a great disadvantage to the countries in which it takes place.

Black, in *Painting;* the darkest of all colours. This colour absorbing all the rays of light and reflecting none, occasions its darkness. There are several species of blacks used in painting, of which the following are the principal:—Frankfort black, of which there are two sorts, one a natural earth inclining to blue; and the other made from the lees of wine burnt, washed, and ground with ivory, bones, or peach-stones. This black is much used by the copperplate printers, for their fine ink to work their engravings. Ivory black is burnt ivory, or bones reduced to powder, and ground in oil or water as required. Spanish black is burnt cork reduced in a similar manner. Harts black is that which remains in the retort after the spirits, volatile salt, and oil, have been extracted from hartshorn. Lamp black is generally prepared in England at the turpentine manufactories, by burning the dregs after the refining of pitch or other resinous matter, in furnaces constructed for the purpose.

Bladder, in *Anatomy;* a membranous bag, serving as a reservoir for some secreted fluid.

Blanket, in *Commerce;* a warm woollen sort of stuff, light and loose woven; chiefly used in bedding. The best blankets are from Witney in Oxfordshire, where the manufacture of them has attained great perfection.

Blast-Furnace; a large conical or quadrangular building, used at iron works for smelting iron-stones and ores.



When employed for chemical purposes, a different sort of apparatus is required. The apparatus best fitted for the laboratory is represented above.

To excite a sudden heat, and to raise it rapidly to the greatest intensity, nothing can be better calculated than this simple furnace. By the ingenious contrivance of dividing a strong blast of air, issuing from a double bellows, and driving it forcibly, first into a small chamber and from thence perpendicularly into a number of converging jets, through the centre of the fire-place, a most intense heat is produced, sufficient to melt down cast-iron, if the fire be properly managed, and the bellows worked with vigour. Coke or cinders, free from clinkers and dust, taken from the common grate, when the coal just ceases to blaze, broken into fragments of the size of a walnut, and mixed with a little charcoal, form an excellent fuel for this furnace; the fire being first kindled by a few lighted cinders and a small quantity of charcoal or chips of wood. This furnace is composed of three parts, all made of black lead. The lower part contains the blast chamber; to this is fitted the body of the furnace which is perforated with blast holes at the bottom; the upper part, or dome inverted, serves to concentrate the heat with more efficacy, and to make it reverberate on the bodies exposed to it; it also protects the eye from the intolerable glare of the fire when the furnace is in full heat; a pair of double bellows is fixed on the stool; the handle, is lengthened to make them work easier. If a very strong blast be wanted, a heavy weight may be secured to the upper board of the bellows.

Blasting; the technical term for splitting any object by means of gunpowder.

Blazoning, or Blazonry, in *Heraldry;* the deciphering of coats of arms, from the German *blasen*, to blow, because the herald blew a trumpet, and called out the arms of a knight, when he entered the lists at a tournament.

Bleaching; a very important chemical process. According to the old system, it was a tedious and unpleasant process, comprising a number of operations, conducted in the following manner: 1, steeping and milling; 2, bucking and boiling; 3, alternate watering and drying; 4, scouring; 5, rubbing with soap and warm water; 6, starching and bluing.

In the first of these operations, the cloth intended to be bleached, disposed in folds, is put into warm water, where it is allowed to remain until the air bubbles, which, after eighteen hours' steeping, begin to arise on the surface, have disappeared; this generally happens, according to the warmth of the weather, in from fifty to seventy hours; if allowed to remain longer, a scum which forms on the surface of the water would precipitate, and the steeping must be discontinued before this occurs. After the steeping, the cloth is taken to the mill, in which by continued agitation with a large quantity of water, all the loose foulness is carried off.

In the bucking and boiling, alkaline leys are employed to remove that particular substance which occasions the brown colour of the cloth. Potash is the alkali mostly employed. The ley is at first put on the cloth only blood warm, it is then drawn off, and poured on at a greater heat. The cloth is next taken into the field and spread out, where it is watered at intervals sufficiently short to keep it constantly wet; for if allowed to dry, while strongly impregnated with alkaline salts, the texture of the cloth would be injured. After this has been attended to, about half a day, dry spots are allowed to appear before the watering is repeated. By this process, the cloth acquires a greater degree of whiteness than before it was taken out, and where the evaporation has been strongest, as on the upper side of the cloth, the colour is whitest. After the cloth has received in the field a tolerably good and uniform colour, as is fit for souring, in which operation it is steeped in sour milk, or in water soured with bran or rye-meal, and used new-milk warm; or what is still better, in water acidulated with sulphuric acid. After being sufficiently soured, which is accomplished in a few hours, the acid is entirely removed by washing in the fulling-mill, and the cloth is then washed by the hand with soft soap and warm water. Coarse cloths are washed more slightly; being rubbed over with soap, they are worked between boards, called rubbing-boards, which effect the purpose by the grooves they contain. The finishing operations of starching and bluing, are conducted in a similar manner to the starching and bluing of the laundry.

The various steepings, boilings, and exposures to the air, to be performed in the process of bleaching above described, consumed much time, and the manufacturer was besides very dependant on the state of the weather; but while the nature of the change produced on the linen was not understood, there appeared but little hope of materially shortening the period employed in completing. The progress of discovery, however, in chemistry, at length threw a ray of light upon the subject, and in a short time the theory of bleaching became better known, and the practice entirely changed. We are indebted to Mr. Hall, of Nottingham, for the first useful employment of the art of chemistry in bleaching. Prior to his time it was a mechanical trade, but that ingenious chemist converted it into a scientific process, which we may now proceed to describe. When a coloured piece of cloth is exposed to the action of oxymuriatic acid, the colour entirely disappears in a longer or shorter period, and the acid, if the quantity of cloth upon which it has been exerted, is sufficient to exhaust it, is reduced to the state of common muriatic acid. It is evident, then, that the colouring matter has lost its property of exhibiting colour by combining with oxygen; and when the cloth thus bleached has been for some time exposed to the air, it becomes yellowish, because part of the oxygen which had combined with the colouring matter flies off. An additional process therefore is necessary, and as it was found that the action of the oxymuriatic acid rendered the substance of the colouring matter soluble in alkaline lixivia, by the employment of such lixivia, a permanent white is obtained. In this new mode of bleaching, the oxymuriatic acid effects, almost immediately, a change, which exposure to the atmosphere requires many weeks to accomplish, and therefore the whole process is prodigiously accelerated. Much complaint was at one time heard, with respect to the injury sustained by the cloths in the new mode of bleaching, and often with justice, as in the infancy of the discovery the want of experience was necessarily attended by the liability to error; and the want of skill, among many who were anxious to adopt it, with a view to commercial advantage, this was often very considerable. But, when properly conducted, it is found to be less injurious to cloth than the old mode, at the same time that it produces a much superior white.

The oxymuriatic acid for the use of the chemist, is

usually obtained by distilling muriatic acid off the the black oxide of manganese; but Berthollet suggested, for the use of the bleacher, the more economical method of obtaining it by the decomposition of muriate of soda, which is effected by diluted sulphuric acid, and the oxide of manganese being added to the mixture, the muriatic acid is produced, and oxygenized at the same time. The following proportions of the ingredients are considered by most to be as the best:

	Parts
Manganese	3
Common salt	8
Sulphuric acid	6
Water	12

The proportion of manganese must be varied according to its quality. The different ingredients should be intimately mixed, and distilled in leaden, earthen, or glass retorts. The distillation should be carried on very slowly, and heat need not be applied till the first disengagement of gas has ceased, after which a sand-bath may be employed, or if the retort be of lead, it may be placed in a vessel of boiling water. The retort must be connected with a receiver, which is designed to collect the muriatic acid that may come over in the first instance, and from this receiver proceeds a tube, the other extremity of which enters a cask of water nearly at the bottom. By this means the gas has to rise through a considerable body of water, which is necessary, as it does not combine very readily with that fluid; its absorption is at the same time promoted by the motion of a circular frame placed in the middle of the cask, and whirled by a handle placed at the top. The intermediate vessel for the retention of the muriatic acid may be dispensed with, by using a long-necked retort which will condense this acid, and it may be caused to run back by giving a suitable inclination to the neck of the retort. By this means the solution of the acid can be made as strong as may be required. It requires to be stronger for coarse than for fine cloth, and for linen than for cotton. The average produce is stated by Berthollet, at 100 quarts for every pound of muriate of soda that has been used. The strength of the bleaching liquor may be tried by dropping a given measure of it into a tincture of cochineal, or a solution of indigo in sulphuric acid, of a certain strength, and by observing the discolouration produced, its strength is known. The cloth is prepared for bleaching by keeping it for some hours in a bath of warm water, and afterwards boiling it in an alkaline ley, containing 20 parts of water and 1 part of potash, rendered caustic by one-third of lime. After this preparation, which opens its pores, removes the soluble part of the colouring matter, and thus prevents an unnecessary waste of oxymuriatic acid, it must be disposed in the bleaching liquor in such a manner that every part may be equally exposed to its action. It is then, alternately, exposed to the action of the bleaching liquor and the alkaline ley, till it is observed to be sufficiently bleached; from four to eight immersions will be required, according to the texture and kind of the cloth, and the colours to be destroyed. Cotton is so much more easily bleached than linen, that when the liquor has little effect on the latter, it will answer perfectly well for the former. From the great volatility of the acid, it becomes desirable to employ close vessels, and one which is extremely simple, and answers the purpose perfectly well, was contrived by Mr. T. L. Kupp, and described by himself in the *Memoirs of the Literary and Philosophical Society of Manchester*. It consists of an oblong deal cistern, made water-tight, and the dimensions of which are adapted to the quantity and size of the cloth intended to be bleached at once. This cistern is covered by a lid, which has a rim that goes within the cistern, and fits it with tolerable accuracy, but may, if thought necessary, be farther secured with pitch. Opposite each other, in a line running lengthwise in the middle of the cistern, and at a distance equal to one-fourth of the length of the cistern, are placed two upright axles of beech-wood or ash, one of whose extremities turns in a wooden step or socket, fixed in the lid, above which they project with a square termination for a handle or a pulley to be slipped upon them. Upon each axle is tightly fastened, by sewing to itself, a piece of strong canvass, one end of which, from the top to the bottom, is left projecting a little. To these pieces of canvass, the ends of the web of calico, &c., to be bleached, may be fastened by wooden skewers, and either axle, on being turned by the handle or winch slipped on the square end at the top, will then have the calico wound upon it, and by putting the winch upon the other axle, the web will be transferred to that axle. The axles are taken out of the cistern to fasten the cloth upon them; when they are replaced, the cistern is filled with bleaching liquor: and as by turning the winch, every part of the web is stretched in succession between the two axles, the whole will be equally bleached, which is an advantage that cannot be obtained by simple immersion. While the cloth is winding upon one of the axles, the ready motion of the other might cause it to become slack, and wind unequally; to prevent this, the axle from which it is drawn, has a small pulley slipped upon its square extremity, and a cord with a moderate weight attached, causes sufficient friction to make the winding regular. When the bleaching liquor is exhausted, it is let off by a spigot and faucet even with the bottom of the cistern. On each axle near the bottom of the cistern is a plain cylinder of thin wood, the diameter of which is at least equal to the diameter of the cloth, when entirely rolled upon either axle; its use is to present a shoulder upon which the cloth may rest, and be prevented from slipping down.

Experience must be the workman's guide, in determining how long the cloth must be worked, and teach him to know the effect which a given quantity of bleaching liquor will produce on a certain number of pieces; but this knowledge, with the use of the test liquor, is acquired without difficulty.

This apparatus may easily be adapted to the bleaching of yarn; for example, if the cylinder we have described as being situated near the bottom of each axle, to prevent the cloth from slipping down, be removed to a situation just under the lid, and be perforated with holes in all directions, and tapes or strings, to support the skeins, be passed through these holes, the skeins hanging down towards the bottom of the cistern, may be revolved as if a web was on the axles, and as the motion communicated to each skein will be equal, no entanglement will occur. Several axles, fitted up in this manner, might be connected by pulleys and bands, and turned by a single winch. To fill the cistern, a short pipe is fas-

tened in the centre, or any other convenient part of the lid; and a pipe from the cask in which the bleaching liquor is made, passes through this pipe to the bottom of the cistern; and by adapting stop-cocks to the tubes, the transfer may be made without allowing any gas to escape.

The apparatus invented by Kupp, and which we have described above, was designed to fulfil several important conditions, all of which it secures. It was designed to be simple and economical in its construction; it was required to confine completely the vapours of the oxymuriatic acid, not only to prevent the loss of allowing it to escape, but to prevent the injurious effects which the breathing of these vapours would inevitably have on the health of the workmen. It must also be observed, that as potash when mixed with the bleaching liquor had been found to prevent the escape of noxious vapours, that alkali had been employed as an essential ingredient in the modes of bleaching previously used. But as the quantity of alkali employed, and which was entirely lost, was equal to about one-fourth of the weight of the salt, it made an addition of 40 per cent. to the expense; and instead of increasing the bleaching power of the liquor, by neutralizing a part of the acid, it actually diminished this power; the advantage therefore gained by a mode of using the pure liquor appears of the first importance.

But experience evinced that something was yet required; the oxymuriatic acid alone had the effect of injuring in some degree the fibres of the cloth, and an ingredient was therefore required which should be cheaper than potash, and less injurious to the power of the liquor: the three earths, lime, barytes, and magnesia, were all found to be capable of being used as substitutes, and lime soon obtained a preference on account of its being the cheapest. The first difficulty that presented itself in the use of this earth, arose out of the slight degree in which it is soluble in water; but it was found that all that was wanting could be accomplished by the mechanical suspension of the lime in water, by means of agitation, as when the oxymuriatic gas entered a close vessel where this was done, the oxymuriate of lime, which is soluble in water, was completely formed, and the clear part of the water which contained it in solution, being drawn off from the undissolved or unsaturated part of the lime, was ready for use as a bleaching liquor. Subsequently, a farther improvement was made, which consists in combining the oxymuriatic acid with dry lime, and dissolving a suitable proportion of this compound to form a bleaching liquor. For this invention a patent was taken out, but the exclusive right was contested in the Court of King's Bench, and decided against the patentee. It is, therefore, open to the public, and the use of the oxymuriate of lime, thus obtained, has long been in general use. It is prepared by introducing the oxymuriatic acid, through leaden tubes, into slaked lime made from chalk. The advantages of using this salt, are, that it is easily preserved or conveyed to a distance; it can be purchased by the bleacher ready prepared, and by the solution of more or less of it, he can at all times immediately obtain his liquor of the strength he requires. The strength of the liquor may be known by the hydrometer, or by trying its effect on diluted sulphate of indigo, in the same manner as the solution of the pure oxymuriatic acid is proved; and the apparatus for exposing the cloth to its action may be the same. Objections have been made to the use of the oxymuriate of lime, on the ground of its injuring the cotton for the reception of some colours, and the oxymuriate of magnesia has been recommended as preferable; but as the latter would be six times the price of the former, the difference of expense amounts to its prohibition, unless greater advantages could be derived from the use of it than have yet appeared. When the cloth has been completely bleached, it is rubbed hard with soft soap and warm water, and washed; it is afterwards steeped in warm water, containing from one-sixteenth to one-hundredth part of sulphuric acid. By this means its whiteness is farther heightened, the odour of the oxymuriatic acid which it retains is diminished, and any small quantity of iron or calcareous earth contained in the cloth is carried off.

In the last stage of the process, the cloth is exposed for a few days to the open air in the field, and frequently watered, to remove every trace of the acids which have been employed. The colours of dyed silk or wool may be removed by the bleaching liquor, and the yellowness which it communicates to them may afterwards be removed by exposing them to the fumes of sulphur; but the practice is too hazardous for commercial use.

The use of the alkaline ley, in bleaching, is to carry off the colouring matter which the action of the oxymuriatic acid has rendered soluble, and hence the necessity for the alternate use of the two agents; but as it appeared probable that a cheaper ley, in which colouring matter was soluble, might be found than that of potash, which is usually employed, and proves very expensive; Dr. Higgens, after various conjectures and experiments on the part of himself and others, found the sulphuret of lime well adapted to the purpose. Sulphur and lime are both cheap articles; they are easily combined, and they do not injure the linen. The sulphuret of lime may be prepared in the following manner for the purpose of bleaching: sulphur, or brimstone, in fine powder, four pounds; lime, well slaked and sifted, twenty pounds; water, sixteen gallons; these are to be well mixed, and boiled for about half an hour in an iron vessel, stirring them briskly from time to time. When the agitation of boiling is over, the solution of the sulphuret of lime clears, and may be drawn off free from the insoluble matter, the quantity of which is considerable. The liquor in this state has nearly the colour of small beer, but is not quite so transparent. Sixteen gallons of fresh are afterwards to be poured upon the insoluble dregs in the boiler, in order to separate the whole of the sulphuret from them. The water last added, is boiled, and the dregs well agitated in it, and when it has become clear, it is drawn off and added to the first liquor: thirty-three gallons more of water are then added, and the liquor is afterwards reduced to the proper state for use. When the cloth has been perfectly cleansed from the weaver's dressing, it is steeped in this liquor from twelve to eighteen hours; it is then taken out, and well washed. When dry, it is to be steeped in the solution of oxymuriate of lime eight or twelve hours, and then washed and dried. These processes are repeated, till the cloth has been six times in each liquor, and it is then usually found to be completely bleached. The saving by the use of the sulphuret of lime is considerable.

The oxymuriatic acid has been extensively em-

ployed by paper manufacturers. It appears at first view, to be well adapted to this branch of trade, as it may be supposed that, whether the rags, or the pulp to which they were reduced, is bleached, the large quantity of water employed would effectually remove every trace of the acid; but the fact is otherwise: large quantities of paper, apparently made according to the best process for bleaching, have been rendered unfit for use; and in all bleached paper, the odour of the oxymuriatic acid is more or less perceptible to the smell, when a parcel of it is fresh opened. Different manufacturers are more or less successful in their use of bleaching; but in those cases where the process is so well conducted that the use of the acid can scarcely be suspected, the care bestowed in washing the pulp causes an additional expense almost equal to that of using a more valuable rag without bleaching. The faults commonly attributed to bleached paper, and which in some degree obviously exist, are, that it is not so proper for writing upon, because the size is injured; that in course of time it weakens the colour of writing ink, and its own whiteness diminishes; that it is apt to break in the folds, and from its little coherence, is easily worn away by friction. It is said even to impair the colour of printing ink, but this has not been fully ascertained. If those who are not very well acquainted with the subject, wish to ascertain whether a parcel of paper is bleached or not, they may hold a piece of it to the fire, till it is thoroughly dried, but not browned; then, while it is yet hot, they may suddenly crumple it up in their hands. If the paper retain any injurious portion of acid, it will by this treatment fall in pieces; but if it break in none of the creases, it may be deemed fit for any purpose.

The oxymuriatic acid has been applied to the bleaching of printed books, and impressions of engravings; but if it have the injurious effects upon paper alluded to above, notwithstanding the superior chance of having the acid extracted in the manufacture, it must be obvious that it can only be applied to those which are of little or no value until restored by its use. The paper of an engraving, however soiled, by smoke, ink, &c., may speedily be restored to a brilliant white, by simply immersing it in the oxymuriatic acid, allowing it to remain a longer or shorter time, according to the strength of the acid solution, or the degree in which it is stained. When a volume is intended to be bleached, the binding must be destroyed to separate it into leaves. The leaves are then placed flat in a leaden cistern, and separated from each other by thin slips of glass or wood: or the leaves may be suspended vertically over narrow slips of wood placed very near each other. In either case the acid must be poured in gently by the sides of the vessel, to prevent disarranging the leaves; and when the full effect has been produced on the paper, it should be drawn off at the bottom, and its place supplied by pure water, which should be changed several times, or until the smell and taste of the acid appears to be wholly removed from the paper. Chaptol observes, that when he had to bleach prints so torn that they exhibited only scraps pasted upon other paper, he was afraid of losing these scraps in the liquid, because the paste became dissolved. In such cases, he enclosed the prints in a cylindrical glass vessel, which he inverted in the water on which he had put the mixture proper for extricating the oxymuriatic acid gas. This vapour, by filling the whole inside of the jar, acted upon the print; extracted the grease and ink-spots, and the fragments remained pasted to the paper.

When for such purposes as bleaching prints, a small quantity of the oxygenated acid is required, without the trouble which would attend obtaining it by distillation, it will suffice to add the black oxide of manganese, or the red oxide of lead, to common muriatic acid diluted with water. The bottle in which the mixture is made should be strong, or its stopper not made very fast, as the elastic vapour which is extricated might otherwise cause an explosion. At the end of two or three hours the acid will have become colourless, and may be used after a little farther dilution. It has an acid taste, because not perfectly saturated with oxygen.

To bleach old printed paper, for the purpose of being worked up again, Pajot des Charmes directs the paper to be boiled for an instant in a solution of caustic soda. That from kelp may be used. Then steep it in soap-suds, and wash it; after which it may be reduced to a pulp. The soap may be omitted, if it be thought proper.

For old written paper to be worked up again: steep it in water acidulated with sulphuric acid, and then wash it well before it is taken to the mill. If the water be heated, it will be more effectual.

To bleach printed paper, without destroying its texture: steep the leaves in a caustic solution of soda, either hot or cold, and then in a solution of soap. Arrange them alternately between cloths, as paper-makers do their sheets of paper when delivered from the form, and subject them to the press. If one operation does not render them sufficiently white, it may be repeated as often as necessary.

To bleach old written paper, without destroying its texture: steep the paper in water acidulated with sulphuric acid, either hot or cold, and then in a solution of oxymuriatic acid; after which immerse it in water, that none of the acid may remain behind. This paper, when pressed and dried, will be fit for use as before.

Bleeding, in *Surgery*, is the artificial extraction of blood from an artery or vein, for medicinal purposes. The operation of cutting an artery is termed arteriotomy; that of opening a vein, is called venesection, or phlebotomy.

The instrument used in this country for bleeding the human subject, is denominated a lancet; though a phleme, or fleam, was formerly employed, and is still very commonly used by farriers in England, and even by the best surgeons in Germany. The lancet, on these occasions, is used single; but where the intention is to puncture numerous small blood-vessels at the same instant, rather than any one considerable vein or branch of an artery, surgeons have recourse to an instrument containing many lancets, which is known by the name of scarificator.

The art of bleeding may be traced back to the remotest antiquity, and seems to have been common among the Egyptians, Assyrians, Scythians, &c., at a time when anatomy had never been cultivated. The Greeks boast that Podalirius, the son of Esculapius, was the first who practised bleeding, soon after the siege of Troy; but the fact itself is related by only one author, who lived too long afterwards to be credited implicitly. It is, therefore, much more likely, that bleeding had been performed previously to the time alluded to. Pliny, indeed, supposes that

physicians first learned this operation from having observed the hippopotamus draw blood by pushing sharp reeds into its body; but this is a very improbable thing, as there is very little analogy between the artificial opening of a vein with a lancet, and the random wounding of an animal by friction against a broken reed.

When we resolve to perform venesection, we must, besides the instruments required for that operation, have in readiness one or two well-rolled blood-letting bandages, or tapes, from four to eight feet in length, and of two fingers' breadth, with pins, or else needles and thread. Those bandages are, by foreigners, reckoned the best, which have narrow straps at their ends.

In general, venesection is practised at the bend of the elbow, or upon the foot; this being previously drawn moderately tight, a bow is tied with a single knot, at the posterior part of the arm. Whether this bandage has been properly applied, we know by the circumstance, that the veins become elevated and tumid, whilst the pulsation of the artery at the wrist is distinctly perceptible.

We then choose a vein in the bend of the elbow, which must be done with caution. The upper is the cephalic vein, and this a beginner ought, if possible, always to choose, as little or no danger is to be apprehended from opening it, but it is very seldom to be seen or felt, and commonly is too small. The median vein is most easily seen and felt; but generally the tendon of the biceps muscle is situated under, or at the side of it, which we must take great care not to puncture.

Blight, in *Agriculture;* a general name for various distempers incident to corn and fruit-trees.

It affects them variously, the whole plant sometimes perishing by it, and sometimes only the leaves and blossoms, which will be scorched and shrivelled up, the rest remaining green and flourishing. Some have supposed that blights are produced by easterly winds, which bring vast quantities of insects' eggs along with them from distant places. These being lodged on the surface of the leaves and flowers of fruit-trees, cause them to shrivel up and perish.

Mr. Knight, however, observes, that blights are produced by a variety of causes; by insects, by an excess of heat or cold, of drought or moisture; for these necessarily derange and destroy the delicate organization of the blossoms; but he believes the common opinion, that they arise from some latent noxious quality in the air, or from lightning, to be totally unfounded. The term blight is very frequently used by the gardener and farmer, he remarks, without any definite idea being annexed to it. If the leaves of their trees be eaten by the caterpillar, or contracted by the aphis; if the blossoms fall from the ravages of insects, or without any apparent cause, the trees are equally blighted; and if an east wind happen to have blown, the insects, or at least their eggs, whatever be their size, are supposed to have been brought by it.

Blind, the; such as are deprived of their sight. The loss of the noblest sense, by means of which man receives an idea of the world that surrounds him, clothed in light and colour, is an event as melancholy as it is frequent. Blindness is different, 1. in its degrees; some persons being partially blind, retaining a slight perception of light, with the power of distinguishing very brilliant colours, and the general outlines of bodies; others being entirely deprived of the faculty of seeing; 2. in its causes: some men are blind from their birth; others have become blind by local diseases of the eyes; for instance, by inflammation, suppuration, cancer of the eye-ball, spots, films, tumours on the cornea (by which its transparency is destroyed), also by closure of the pupil, by a turbid state of the humours, by a debility of the optic nerve, or by general diseases of the body, violent fevers, nervous fevers, plethora, and tendency of the blood to the head, erysipelas in the face, small-pox, scarlet fever, &c., or by excessive exertion of the eyes, by which the optic nerve is enfeebled; for which reason, some classes of mechanics and artists, as blacksmiths, labourers in glass and smelting-houses, watch-makers, &c., not unfrequently lose their sight; and in northern countries, which are covered with snow for a long time, and which dazzle the eyes by the reflection of the sunbeams, as well as in the sandy deserts of Africa, blindness is a frequent complaint. Old age is sometimes accompanied with blindness, occasioned by the drying up of the humours of the eye, or by the opacity of the cornea, the crystalline lens, &c. There are several causes which produce blindness from the birth. Sometimes the eyelids adhere to each other or to the eye-ball itself, or a membrane covers the eyes; sometimes the pupil of the eye is closed, or adheres to the cornea, or is not situated in the right place, so that the rays of light do not fall in the middle of the eye; besides other defects. Those who are born blind have no idea of vision, and are entirely destitute of all the ideas derived from the sense of sight. They cannot, therefore, be sensible of their misfortune in the same degree as those who have lost their sight at a later period. Experience has shown, that those who acquire the power of seeing after being born blind, or having lost their sight in their childhood, form very different ideas of visible objects from other persons.

A young man, whom Chelenden couched for a cataract, at the moment he received sight, imagined that all the objects which he saw were in contact with his eyes: he could not distinguish objects, although of very different forms. Those with which he was already familiar by the touch, he examined with great attention, in order to recognise them another time; but, having too many things to notice at once, he soon forgot all that he had observed. He wondered that those persons whom he loved most were not handsomer than others. Before he received his sight, he had expressed a great desire to obtain this sense. The other senses of persons, who have been blind for a long time, become more exquisite, perhaps, because they are not subject to the distraction produced by the sight of so many objects. The blind, therefore, are often distinguished for a remarkable mental activity, and a wonderful developement of the intellectual powers. Their touch and hearing, particularly, become very acute. Thus it is related of a blind man, who lived at Puisaux, in France, and was a chemist and musician, that he could accurately estimate the proportions of objects, could judge of the distance of fire by the degree of heat, determine the quantity of fluid in vessels by the sound it produced while running from one vessel into another, and the proximity of objects by the effect of the air upon his face. He determined very accurately the weights of bodies and the capacities

of vessels. The celebrated Saunderson, professor of mathematics at Cambridge, lost his sight in his early youth. He invented several processes to facilitate his studies in arithmetic and geometry. His sense of touch was so acute, that he distinguished spurious coins merely by letting them pass through his fingers, though they were so well executed, that even skilful judges were deceived by them.

Blind, Institutions for the. In the case of persons destitute of sight, it is necessary to have recourse to the other senses to supply the want of the eye. If, for instance, we wish to teach them the arts of reading and writing, letters must be prepared, which will be palpable to the touch, and the hand guided until they are able to copy them. If we wish to communicate to them a knowledge of the surface of the earth, globes and maps must be prepared with the divisions, &c., in relief. Knowledge obtained in this way must, of course, be acquired much more slowly than that received by the sight. The senses of touch and of sight differ in this respect, that the of former ascends by degrees from the perception of parts to the perception of the whole, whilst the latter views the whole at a single glance. It is, therefore, evident, that the blind cannot be instructed in the common schools destined for those who see: in the first place, because the means of instruction by the touch are wanting; and secondly, because the progress of the other children would be retarded by the slow apprehension of the blind pupils. For these reasons, and as the blind form no small part of the population of every country, particular institutions have, in many places, been established for their instruction. In Prussia, they amount to more than 13,000 souls. Zeune, in his *Belisar*, has laid down, as a general law, deduced from observation, that the proportion of blind persons decreases from the equator towards the poles. In Egypt, he says, it is as 1 to 100, while in Norway the proportion is 1 to 1000.—The instruction given in the schools for the blind aims, first, at a general cultivation of their intellectual faculties. They are afterwards taught some art which may enable them to provide for their own subsistence. These arts are of two kinds—mechanical employments and music. The instruction of the blind, therefore, embraces three branches—1. mechanical labours; 2. the fine arts; 3. science; because it is impossible to determine, without trial, the peculiar genius of the pupils, whether, for instance, they should be instructed as mechanics, musicians, or mathematicians. The German institutions for the blind, as well as those in Paris, have this comprehensive character, whilst the English aim, more exclusively, to impart instruction in mechanical trades. The first idea of such an institution for blind persons was conceived by Valentin Haüy, brother of the celebrated mineralogist: it was suggested to him by his acquaintance with a blind German lady, the Baroness von Paradis, of Vienna, who visited Paris in 1780, and performed on the organ with general applause. Haüy repeatedly visited this ingenious lady, and was much surprised to find in her apartments several contrivances for the instruction of the blind; for instance, embroidered maps and a pocket printing apparatus, by means of which she corresponded with von Kempelen, in Vienna (the inventor of the chess-player and speaking automaton), and with a learned blind gentleman, named Weissenburg, at Manheim. Haüy compared the high cultivation of these two Germans with the degraded state of the blind in France, where, at the annual fair of St. Ovide, an innkeeper had collected 10 poor blind persons, attired in a ridiculous manner, and decorated with asses' ears, peacocks' tails, and spectacles without glasses, to perform a burlesque concert. Nor did the great institution for the blind, or the hospital of the 300 (commonly called *les quinze-vingt*, founded, in 1260, by St. Louis, after his crusade to Egypt, during which so many soldiers became blind by the ophthalmia, prevailing in that country), present to the philanthropic Haüy a pleasing picture of intellectual cultivation; rather a scene of dulness and moral corruption. He, therefore, resolved to do for the blind in France what the Abbé de l'Epée had done for the deaf and dumb. In 1784, he opened an institution, in which they were instructed, not only in appropriate mechanical employments, as spinning, knitting, making ropes or fringes, and working in pasteboard, but also in music, in reading, writing, ciphering, geography, and the sciences. For this purpose, he invented particular means of instruction, resembling those with which he had become acquainted by his intercourse with the two blind Germans, Paradis and Weissenburg. For instruction in reading, he procured raised letters of metal, from which, also, impressions may be taken on paper: for writing, he used particular writing-cases, in which a frame, with wires to separate the lines, could be fastened upon the paper: for ciphering, there were moveable figures of metal, and ciphering-boards, in which the figures could be fixed: for teaching geography, maps were prepared, upon which mountains, rivers, cities, and the borders of countries, were embroidered in various ways, &c. In the beginning, the Philanthropic Society paid the expenses of 12 blind persons; afterwards, in 1791, the institution was taken under the protection of the state, and united to that for the deaf and dumb; but, as this was found inconvenient, it was, in 1795, separated from the latter, and, in 1801, united to the hospital of the *quinze-vingt*. The mingling of young blind persons here with old soldiers being found very prejudicial to the former, Haüy, full of indignation, went to Petersburg, in 1806, in order to establish a similar institution there. After the restoration, in 1815, the establishment was put upon its original footing, and the physician Dr. Guillié appointed its director.—Next to France, the first institutions for the blind were established in Great Britain, where, however, they are supported only by the contributions of private individuals. In 1790, an institution of this sort was established at Liverpool, in which both males and females are instructed in manual labours, in singing hymns, and playing on the organ. In 1791, a second one was established in Edinburgh, in which the making of baskets and ropes is the principal occupation. Similar institutions have since arisen in other places; one at London, in 1800; also at Dublin, Bristol, and Norwich.—In Germany, the first public institution for the blind was established by the king of Prussia at Berlin, in 1806, when Haüy passed through this city. Zeune was appointed director of it. He invented many instruments more simple than those which had formerly been used, and which answered the purpose very well. Among other things, he brought to great perfection maps and globes, destined for the use of the blind; which, in many parts

of Europe, are used for the instruction of others also, since they present, by means of elevations and depressions of the surface, proportional elevations and pictures, which strike the mind forcibly. In arithmetic, he directed his attention almost exclusively to mental calculations. The first institutions for the blind in Germany, after that in Berlin, were established in Vienna and Prague, both in 1808, and, in the same year, that in Amsterdam, founded by Freemasons. In 1809, the institution in Dresden sprang up—a branch of that in Berlin. In 1810, the institution in Zürich was founded by the auxiliary society. In 1811, a similar establishment was instituted in Copenhagen, after the plan of Professor Brorson, by the *Society of the Chain*, as it is called, (*Verein der Kette*.) After the great war for liberty, from 1813 to 15, when the Egyptian ophthalmia raged so dreadfully among the European armies, several institutions for blind soldiers were established, on Zeune's plan, in Prussia. Their object was to instruct soldiers who had become blind, and unable to exercise their former business, in useful labours. These schools were, at first, intended to continue only till all the soldiers received in them had thoroughly learned some trade: two of them, however, those at Breslau and Konigsberg, have been put upon a permanent footing.

The institution for the blind in Petersburg, which was established by Haüy, but was never in a very prosperous state, seems to have declined greatly, after its founder's return to France, in 1816. The name of its present director is Martin Pilazki. Whether the institution projected at Barcelona, in 1830, has been established, or whether it survived the political storms of that year, or the yellow fever of the succeeding, we do not know. Institutions for the blind are confined almost entirely to Europe, and they appear to be peculiar to Germany, Switzerland, Holland, Denmark, France, England, and Russia. Father Charlevoix, indeed, says, that, in Japan, the records of the empire are committed to the memory of the blind; and Golownin estimates their number in the gigantic city of Jeddo, alone, at 36,000; but neither of them mentions that there is any institution established for them. The director of the institution in Vienna, F. W. Klein, has published a good *Lehrbuch zum Unterrichte der Blinden*, &c. *um sie zu bürgerlicher Brauchbarkeit zu bilden* (Elementary Work for the Instruction of the Blind, &c., to render them useful Citizens).—The first, and as yet the only institution of the kind in America, was commenced in Boston, in the year 1829. In the beginning of that year, an act of incorporation was granted by the legislature of Massachusetts, to several gentlemen, authorizing them to establish the New England Asylum for the Blind, for the purpose of educating blind persons. We understand that this institution is going on prosperously.

Blinds, in operations against fortresses; the name of all preparations which tend to intercept the view of the enemy. There are several species:—1. A fascine placed across the embrasures, to prevent the enemy from observing what passes near the cannon. —2. Blinds before port-holes, are shutters made of strong planks, which are placed before the port-holes, as soon as the guns are discharged, to obstruct the enemy's view.—3. Single and double blinds. The former consist of three strong perpendicular posts, 5 feet in height, between which are planks covered with iron plates on the outside, and thus made shot-proof. This screen is furnished with rollers, to enable the labourers in the trenches to push it before them. The latter consist of large wooden chests, on four block-wheels, which are filled with earth, or bags of sand, and serve likewise in the trenches, &c., to cover the soldiers from the fire of the enemy.—4. Another kind of blinds used to protect the workmen in the trenches, are the chandeliers. Two square beams of timber are placed parallel, and at a distance of six feet, on the ground, and fastened by two cross beams. Upon the ends, perpendicular posts are erected, and the interval is filled up with fascines, at least to a height of five feet.—5. *Blind* is also the name given to coverings placed over the most exposed parts in the approaches or the fortress. These are made of beams, over which hurdles or fascines are spread, that finally receive a sufficiently thick layer of earth as a cover.

Blister, in *Pharmacy*. Blisters are raised on the surface of the body for medicinal purposes, by applying for a number of hours some of the most active of the animal or vegetable stimulants. Of these, by far the most convenient, and that which is most universally employed, is the cantharides, or Spanish fly. These insects are found in Spain, Italy, and the south of Europe; they have a longish body, beautifully brilliant with green and gold. They are gathered by shaking the trees which they frequent, and are killed by the vapour of spirit of wine burnt beneath them, or by the fumes of vinegar, after which they are dried in a stove. In this state they are brought over without farther preparation. For blistering the skin, the cantharides are first finely powdered, and then incorporated with a mixture of wax and resin melted together. The plaster thus made, is spread uniformly upon leather with an iron spatula.

Blocks are pieces of wood in which sheaves or pulleys are placed, for the purpose of forming tackle, purchases, &c., in various operations in naval tactics and architectural constructions. This mechanical power is described in the article **Pulley**. Blocks are single, double, treble, and fourfold, according as the number of sheaves is one, two, three or four. The sheaves are grooved to receive the rope, and have in their centre a brass *bush*, or triangular piece of brass, to receive the *pin* on which they revolve. The sides of the block are called *cheeks*. A *running* block is attached to the object to be moved; a *standing* block is fixed to some permanent support. An example of a block with two pulleys is furnished in the accompanying figure. Blocks also receive different denominations from their shape, purpose, and mode of application. No less than 200 different sorts and sizes are made at Portsmouth for the royal navy, besides which there are various sorts used only in the merchant-ships. The machinery for supplying the royal navy with blocks is the invention of Mr. Brunel. It enables four men, in a given time, to complete the shells of as many blocks as 50 men could do by the old method. Indeed, the block machinery at Portsmouth is justly considered as one of the wonders of the world.

Blockade, is the interception by one belligerent

of all communication with a place occupied by another. National sovereignty confers the right of declaring war, and the right which nations at war have of destroying or capturing each other's subjects or goods, imposes on neutral nations the obligation not to interfere with the exercise of this right within the rules and limits prescribed by the law of nations. In order to render the communication with a place unlawful to a neutral, a blockading or besieging force must be actually present, investing it, and sufficiently powerful to render a communication with it dangerous to a neutral, and expose him to seizure by the blockading or besieging force. A declaration of siege or blockade is an act of sovereignty, but does not require in all cases, a direct declaration by the sovereign authority of the besieging belligerent; for its officers may be invested, either expressly, or by implication, with authority to institute such siege or blockade. It must, however, in order to be lawful and obligatory on neutrals, be declared, or sanctioned, either expressly, or by implication, by the sovereign power. It must also be declared or made public, so that neutrals may have notice of it. If a blockade is instituted by a sufficient authority, and maintained by a sufficient force, a neutral is so far affected by it, that, if he attempts to trade with the place invested, either by carrying goods to it or bringing them away, the property so attempted to be carried to, or from the place, is liable to be seized by the investing party, and, in case of being seized, is forfeited.

BLOCKHOUSE, in *Fortification;* a house made of beams, joined together crosswise, and often doubled, with a covering and loop-holes, large enough for 25 or more men. In addition to this, it is commonly covered with earth, to render it entirely bomb and and fire-proof. It is usually sunk several feet into the ground. Some forts of this kind contain two stories; and they are often fitted up to receive cannon. Blockhouses are generally built in the form of a square or a cross. Their use is to afford a feeble garrison of an important place, which is very much exposed, an opportunity of holding out against the cannonade and assault of the enemy till they are relieved. They also serve for bomb-proof guard-houses, and places of last resort, in the interior of intrenchments, and in the covered passages of fortresses, where the cannon are stationed.

BLOCKING COURSE, in *Architecture;* the course of stones or bricks erected on the upper part of a cornice to form a termination.

BLOMARY, or BLOOMARY, the first forge in an iron-work, through which the metal passes after it is melted out of the ore. See IRON.

BLOOD is the red fluid contained in the blood-vessels of animal bodies. It is found in the mammalia, in birds, in reptiles, and in fishes. In the last two classes of animals, the temperature of the blood is much lower than in the former, for which reason they are distinguished by the name cold-blooded, while the others are termed warm-blooded animals. Insects and worms, instead of red blood, have a fluid of a whitish colour, which is called white blood. In the blood, two different substances are contained, which are separated by coagulation—the serum, a fluid like the white of an egg, and a thick matter, to which the red colour properly belongs, which is much heavier than the former, and is called the coagulum. The last may be divided again into two different parts—into the cruor, or that part of the blood which is intrinsically red, and coagulable, and lymph or fibrine, to which the coagulation of the blood must be ascribed. The fibrine, in young animals, is much whiter than in older and stronger ones. The blood of the latter contains much more azote than that of the former. If the nourishment of animals is changed, we also find an alteration in the constituent parts of their blood. It is also changed by diseases. In animals that are hunted to death, or killed by lightning, the blood does not coagulate. The blood of birds is more highly coloured, and warmer, than that of viviparious animals, and coagulates more easily in the air. That of reptiles and fishes coagulates with difficulty. Aided by magnifying glasses of a strong power, one may observe, in examining the blood of the living animal, or in blood which is newly drawn, that it consists, especially the cruor, of little globular bubbles, the globules of the blood, as they are called, the diameter of which amounts to about the three hundredth part of a line. In blood that has been drawn some time, although this time may be very short, they are not so strongly apparent. They are the effect of the life that pervades the blood. The more robust and healthy an animal is, the more globules are perceived. They show, as it were, the transition from the formless liquid to the original form of the first organized matter. The blood is of the greatest importance to the life of an animal, and may be considered as a source of life. As long as the body is living, the blood is in perpetual motion. When it is taken out of the body, a remarkable change soon follows: it begins to coagulate, and then undergoes, first an acetous, and, after a few days, a putrid fermentation. All the blood takes its origin from the chyle, and deposits, by degrees, the nourishing particles requisite to the preservation and growth of the body, by a multitude of vessels adapted thereto. This is done while it is driven from the heart into the remotest parts of the body, and from thence back. The circulation of the blood is, as it were, the principle and first condition of life. With it, except in cases of fainting, suffocation, &c., life ceases. The heart, the centre of the circulation of the blood, has a twofold motion, of contraction and dilatation, which constantly alternate. With the heart two kinds of vessels are connected—the arteries and the veins. The circulation of the blood proceeds with an astonishing rapidity: did it flow at an equal rate in a straight line, it would run, in the space of one minute, through about 150 feet. This swiftness, however, exists only in the larger vessels near the heart; the farther the blood recedes from the heart, the slower its motion becomes. In a grown-up person, in good health, we may reckon the mass of blood at from 24 to 32 pounds.

BLOOD-VESSELS are the tubes or vessels in which the blood circulates. They are divided into two classes—arteries and veins—which have two points of union or connection; the first in the heart, from which they both originate, and the other in the minute vessels or net-work, in which they terminate. The arteries arise from the heart, and convey the blood to all parts of the body; the veins return it to the heart. The arteries distribute throughout the body a pure red blood, for the purposes of nourishment; while the veins return to the heart a dark-coloured blood, more or less loaded with impurities, and deprived of some of its valuable properties. But

this is not returned again to the body in the same state: for the heart is wisely divided into two portions or sides, a right and left, one of which receives the impure blood from the veins, and sends it to the lungs to be defecated and freshly supplied with oxygen or vital air, while the other receives the pure red blood from the lungs, and circulates it anew through the arteries. The arteries arise from the left ventricle of the heart by one large trunk, nearly an inch in diameter, which is gradually subdivided into smaller ones, as it proceeds towards the limbs, till they terminate, at last, in vessels so small as to be almost invisible, and in a fine net-work of cells, extending through the whole body, in which the blood is poured out, and nutrition or the increase of the body takes place, and from which the residue is taken up by the small veins, to be returned to the heart. The arteries and veins are widely different in their structure, as well as their uses. The former are composed of very strong, firm, elastic coats or membranes, which are four in number. The external covering and the internal lining of the arteries, although belonging to different classes of membranes, are both very thin and soft. The second coat is very thick, tough, and elastic, being that which chiefly gives their peculiar appearance to the arteries. The third is formed of fibres, apparently muscular, arranged in circular rings round the tube of the vessels. It is well known that the pulse of the heart is felt in the arteries alone, although, in the bleeding of a vein, we sometimes see the blood start as if in unison with the beating of the heart. The pulse is produced by the wave or stream of blood, which is driven by the heart through the arteries, distending and slightly elevating them, after which they instantly contract from their elasticity, and thus force the blood into the smaller vessels. The pulse varies in its character with the general state of the health. (See PULSE.) When arteries are cut or wounded, the firmness of their coats prevents their closing, and hence arises the fatal nature of wounds of large vessels, which will remain open till they are tied up, or till death is produced. The veins commence in small capillary tubes in every part of the body, and, by their gradual union, form large trunks, till they at last terminate in two (one ascending from the lower parts of the body, the other descending from the head and arms), which pour their contents into the heart. Their structure is much less firm than that of the arteries. They are very thin and soft, consisting of only two thin coats or membranes. The inner, or lining membrane, is frequently doubled into folds, forming valves, which nearly close the passage in the veins, and thus give very material support to the blood as it is moving up in them towards the heart. These valves are not found in the veins of the bowels, the lungs, or the head. The number of the veins is much greater than that of the arteries, an artery being often accompanied by two veins. They differ also in this, that, while the arteries are deeply seated in the flesh, to guard them from injury, the veins are very frequently superficial, and covered only by the skin. The veins, it is well known, are the vessels commonly opened in blood-letting, although, in cases which render it necessary, a small artery is sometimes divided. There are two portions of the venous system, which do not correspond exactly with our general description; these are the veins of the bowels and of the lungs. The former circulate their blood through the liver before it returns to the heart, and the latter, the pulmonary veins, convey red blood from the lungs to the heart. (For an account of the circulation of the blood, see ANATOMY and HEART.) It should also be mentioned, that the large vein, which brings back the blood from the lower part of the body, receives from the lymphatic and lacteal vessels the chyle from the bowels, which supplies the waste of the blood, and nourishes the body, and the serous and other watery fluids which are taken up by the absorbents in all parts of the body.

BLOTTING PAPER; a species of paper made without size or stiffening, serving to imbibe the wet ink in account books, &c.

BLOWING, in *Medicine;* a method of administering medicines by inflation, or blowing them into the part affected through a tube; powders are thus conveyed into the eye, and sometimes up the nose, for the cure of a polypus.

BLOWING-MACHINES; the larger instruments or contrivances for producing a strong and continued current of air, such as is necessary in smelting-houses, in large smitheries, &c.

BLOW-PIPE is the name applied to an instrument, by means of which the flame of a candle or lamp is made to produce an intense heat, capable of being applied to a variety of useful purposes. Its most simple form is that of a tapering tube, about eight inches in length, and curved nearly at right angles, within two inches of its smaller extremity. At its larger end, it is nearly a quarter of an inch in diameter, and at the smaller, only large enough to admit a common-sized pin. It is made of brass or light iron. In using it, the flame of a lamp or candle is turned aside from its vertical to a horizontal direction by a stream of air impelled upon it, either from the lungs, or from a double bellows. The flame, in its new direction, assumes a conical shape, and consists of two parts, visible by their different colours; the outer being reddish-brown, and the inner blue. The heat at the apex of the inner cone is the most intense, and is equal to that produced in the best furnaces. It is employed by the jeweller and gold smith in the operation of soldering, and by other artists who fabricate small objects in metal; by the glass-blower in making thermometers, barometers, and other glass instruments; by the enameller, and indeed wherever it is required to subject a small body to a strong heat. The common blow-pipe has undergone a variety of improvements in the hands of the chemist, to whose researches it has proved an excellent auxiliary. These consist, principally, in providing its stem with a bowl, or enlargement, where the moisture of the breath may be condensed and detained; in fitting the smaller end so as to receive a variety of little caps, or hollow cones, with orifices of different diameters, so as to be changed according as a flame is required more or less strong; and in rendering the instrument more portable, by constructing it of several pieces, capable of being taken apart and packed up in the space of a pencil-case. With a part, or with the whole of these improvements, it is used by the chemist to make an examination of any doubtful mineral substance, artificial alloy, or pharmaceutical preparation. This he is capable of conducting (with the aid of a charcoal support, and occasionally a little borax) in a moment's time, and with the loss of the smallest imaginable quantity of the substance. To the analyti-

cal chemist its use is indispensable for enabling him to discover the principal ingredients in a substance, previous to his subsequent operations for ascertaining their relative proportion. (For an account of the blow-pipe in which oxygen and hydrogen gases are employed, see OXY-HYDROGEN BLOW-PIPE.

BLUBBER, in *Physiology;* the fat which invests the bodies of all large cetaceous fish, serving to furnish an oil. The blubber is properly the adeps of the animal: it lies immediately under the skin, and over the muscular flesh. In the porpoise it is firm and full of fibres, and invests the body about an inch thick. In the whale its thickness is ordinarily six inches; but about the under lip it is found two or three feet thick. The whole quantity yielded by one of these animals ordinarily amounts to forty or fifty, and sometimes to eighty or more hundred weight.

The use of the blubber to the animal seems to be partly to poise the body, and render it equiponderant to the water; partly to keep off the water at some distance from the blood, the immediate contact whereof would be apt to chill it; and partly also for the same use that clothes serve us, to keep animals warm, by retaining the natural heat of the body. Its use in trade and manufactures is to furnish train-oil, which it does by boiling down. Formerly this was performed entirely ashore in the countries where the whales were caught; but of late the fishers do not always pursue this course, they bring the blubber home, stowed in casks, and then boil it down.

BLUE, in *Painting;* one of the primary colours. This colour, for the use of painters, is variously prepared; the best is ultramarine, which is prepared from lapis lazuli, finely pulverized by ignition, quenched in a strong acid, and subsequently levigated.

BLUE, PRUSSIAN; a colouring matter, of a pure dark-blue colour, a dull fracture, inodorous and insipid, insoluble in water, spirits of wine or ether; it is soluble only by the action of corrosive alkalies. The discovery of this colour was accidently made, in 1704, by Diesbach, a manufacturer of colours, who, with the intention of precipitating colouring matter from cochineal, with which alum and sulphate of iron were dissolved, procured some alkali from the laboratory of Dippel. This alkali, which Dippel had been heating with some animal matter, produced a beautiful blue precipitate. Dippel discovering that the alkali had acquired this power of forming a blue precipitate of iron on account of its mixture with animal oil, soon learned to prepare it in a more simple way, since all animal substances, and even all vegetables, which contain much azote, will give the same result. It is, however, necessary that all the materials should be perfectly pure, since the purification would be too expensive. The addition of alum gives to this blue more body and a brighter colour. This blue substance is a prussiate of iron (52 parts red oxide of iron, and 48 of prussic acid). The alumine added amounts to from 20 to 80 per cent.; but the greater the quantity, the poorer is the quality of the blue.

BLUNDERBUSS, in the *Military Art;* a short species of fire-arm, with a long bore contrived to carry a number of musket or pistol bullets at once. The blunderbuss is proper to do execution in a crowd, or to make good a narrow passage, or door of a house, staircase, or the like.

BOARD; a piece of timber sawed thin, for the purposes of building.

BOARDING, in *Naval Tactics;* the art of approaching the ship of an enemy so near as to admit of the grapplings, which are fixed on the lower yard-arms, at the forecastle, gangways, &c., being thrown into it, for the purpose of securing the vessels together, and of entering her decks with a detachment of armed men.

BOAT; properly, a vessel propelled by oars. In a more extensive sense, the word is applied to other small vessels, which differ in construction and name, according to the services in which they are employed. Thus they are light or strong, sharp or flat bottomed, open or decked, &c., according as they are intended for swiftness or burden, deep or shallow water, &c. The barge is a long, light, narrow boat, employed in harbours, but unfit for sea. The long-boat is the largest boat belonging to a ship, generally furnished with sails, and is employed for cruising short distances, bringing heavy articles on board, &c. The launch is more flat-bottomed than the long-boat, which it has generally superseded. The pinnace resembles a barge, but is smaller. The cutters of a ship are broader and deeper than the barge or pinnace, and are employed in carrying light articles, passengers, &c., on board. Yawls are used for similar purposes, and are smaller than cutters. A gig is a long, narrow boat, used for expedition, and rowed with six or eight oars. The jolly-boat is smaller than a yawl, and is used for going on shore; a merchant-ship seldom has more than two boats, a long-boat and a yawl. A wherry is a light, sharp boat, used in a river or harbour, for transporting passengers. A punt is a flat-bottomed boat, chiefly used for one person to go on shore from small vessels. A skiff is a small boat, like a yawl, used for passing rivers. A moses is a flat-bottomed boat, used in the West Indies for carrying hogsheads from the shore to ships in the roads. A felucca is a large passage-boat, used in the Mediterranean with from 10 to 16 banks of oars. Scow is an American word, signifying a large, flat-bottomed, heavy boat, about 30 feet long, and 12 wide. In some parts of the United States it is called a gondola.

BODY, in *Physics;* a solid, extended, palpable substance; of itself merely passive, and indifferent either to motion or rest; but capable of any sort of motion, and of all figures and forms.

BOIL; to heat a fluid until it bubbles and becomes changed into vapour. If the requisite heat is applied a sufficient time, bubbles continually arise, until the fluid is entirely consumed. A singular circumstance is to be remarked, that the fluid, in open vessels, when it has once begun to boil, receives no increase of heat, even from the hottest fire; the reason is this, that the additional caloric goes to form steam, and ascends with it into the air. The steam itself when formed, may be raised to a much higher degree of temperature. During the period of boiling, the surface of the fluid exhibits a violent undulating motion, and the stratum of air immediately over it is filled with vapour. The noise which accompanies boiling, arises, without doubt, from the displacing of the steam-bubbles, and varies very much with the nature and situation of the vessel. The vaporization of fluids is, very probably, nothing more than a mechanical union of caloric with the fluid. The degree of heat at which different fluids boil is very different. Spirits boil at the lowest temperature; pure water next; at a still higher temperature, the fixed oils. The degree of heat at which a fluid boils is called its

boiling point. This is used as one of the fixed points in the graduation of thermometers. This point is uniform only in case of complete boiling, and under a uniform pressure of the atmosphere. The influence of this pressure appears from experiments. In an exhausted receiver, the heat of the human hand is sufficient to make water boil; while, on the contrary, in Papin's digester, where the confinement prevents evaporation, it may be heated to 300 or 400 degrees without boiling. Under the common pressure of the atmosphere, the boiling point of rain-water is 212° Fah.; that of alcohol, 174°; that of mercury, 660°; that of ether, 98°. From the experiments of Professor Robinson, it appears, that, in a vacuum, all liquids boil about 145° lower than in the open air, under a pressure of 30 inches of mercury; water, therefore, would boil in a vacuum at 67°. Ether may be made to boil at the common temperature, by merely exhausting the air from the vessel in which it is contained.

Boiled, or Boyled Silks; those which have been put while in the balls, into hot water, to make them wind the better.

Boiseau, in *Commerce;* a measure of two bushels and half of a peck, at Bordeaux in France.

Bole; a fossil of a yellow, brown, or red colour, often marked with black dendrites; found in different parts of Bohemia, Silesia, and Styria, also in Lemnos, and at Sienna in Italy. It is made into pipes for smoking, and vessels for cooling water in hot weather. The *terra sigillata* is nothing but bole.

Bollards; large posts set in the ground on each side of a dock. On docking or undocking ships, large blocks are lashed to them, and through these blocks are reeved the transporting hawsers to be brought to the capstans.

Bomb; a large, hollow, iron ball or shell, formerly often made of cannon-metal, and sometimes of an oval form, with a hole in which a wooden fuse is cemented, and with two little handles. Bombs are thrown from mortars. They are filled with powder and combustible matter (which consists of equal parts of sulphur and nitre, mixed with some mealed powder), and are used for setting fire to houses, blowing up magazines, &c. The charge in bombs of 74 pounds contains from 5 to 8 pounds of powder, and 1 pound of the other composition above mentioned. In bombs of 10 pounds, it amounts to 1 pound of powder and from 2 to 3 ounces of the mixture. The fuse, which is hollow, and filled with powder and other inflammable ingredients, sets fire to the charge. The length and the composition of the fuse must be calculated in such a way that the bomb shall burst the moment it arrives at the destined place. Bomb-shells are cast somewhat thicker at the bottom than above, that they may not fall upon the fuse and extinguish the fire; yet they are, at present, often cast of an equal thickness in every part, because it has been found that the fuse remains at the top, notwithstanding. As early as the seventh century, balls filled with burning matter, were thrown from vessels of clay, then from machines called blydes or manges, or with hand-slings made of a small net of iron wire. In 1238, James I. king of Arragon used, at the seige of Valencia, a kind of large rockets, made of four parchment skins, which burst in falling. Afterwards, large iron balls, heated red hot, came in use. In the middle of the fifteenth century, prince Ramini Sigismund Pandulf Malatesta invented mortars and bombs. They consisted, at first, of two hollow hemispheres of metal, filled with powder, and held together by chains. By degrees they received their present shape. An English engineer, Malthus, whom Louis XIII. took into his service, introduced them into France, and used them first (1634) at the sige of Lamotte, in Lorraine. The grenades, which are thrown from howitzers, are easily distinguished from the bombs, which are cast from mortars. The first are used only in the field, the latter in sieges. The Prussian general von Tempelhoff has attempted to bring 10-pound mortars into the field. In order to make a wall bomb-proof, it should be three feet and a half thick.

Bomb-Ketch; a vessel built for the use of mortars at sea, and furnished with all the apparatus necessary for a vigorous bombardment. Bomb-ketches are built remarkably strong, to sustain the violent shock produced by the discharge of the mortars. The modern bomb-vessels generally carry two 10-inch mortars, four 68-pounders, and six 18-pound carronades; and the mortars may be fired at as low an angle as 20 degrees; their principal purpose, at these low angles, being to cover the landing of troops, and protect the coast and harbours. A bomb-ketch is generally from 60 to 70 feet long, from stem to stern, and draws 8 or 9 feet of water, carrying two masts, and is usually of 100 to 150 tons burden. The tender is generally a brig, on board of which the party of artillery remain till their services are required on board the bomb-vessels.

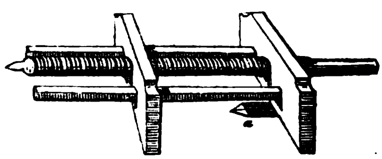
Bone. The bones are the hardest and most solid parts of animals; they constitute the frame, serve as points of attachment to the muscles, and afford support to the softer solids. They are the instruments, as muscles are the organs, of motion. In the mammalia, birds, fish, and reptiles, the whole system of bones united by the vertebral column is called the skeleton. In the fœtus, they are first a vascular gelatinous substance, in different points of which earthy matter is gradually deposited. This process is perceptible towards the end of the second month, and at the time of maturity, the bone is completely formed. After birth, the bones become gradually more solid, and in the temperate zones, reach their perfection in men between the ages fifteen and twenty. From this age till fifty, they change but slightly; after that period they grow thinner, lighter, and more brittle. Those of the two first classes of animals are harder on their exterior than they are internally. Their material, except in the teeth, is nearly the same throughout. Their structure is vascular, and they are traversed by the blood-vessels and the absorbents. They are hardest at the surface, which is formed by a firm membrane, called the periosteum; the internal parts are cellular, containing a substance called marrow. The use of the marrow is to prevent the too great dryness and brittleness of the bones. Chemistry decomposes bone into gelatin, fat, cartilage, and earthy salts. A fresh bone boiled in water, or exposed to the action of an acid, gives out its gelatin; if boiled in water, on cooling the decoction, a jelly is formed which makes a good portable soup. A pound of bone yields twice as much as the same quantity of flesh. The earth of bones is obtained by calcination; that is, by exposing them to a red heat, by which they are deprived of the soft substances. That part of anatomy which treats of the bones is called osteology. See Anatomy.

Bonnet, in *Fortificatian;* an elevation of the parapet in the salient angles of a field intrenchment, or of

a fortification, designed to prevent the infilading of the front of the work, at the end of which it is situated. The bonnet accomplishes, however, only part of this object, and is subject, at least in field intrenchments, to the disadvantage, that the men destined for its defence are too much exposed to be taken in flank by the fire of the enemy, on account of the necessary elevation of the banquette, a fault which cannot occur in the works of a fortress which are well laid out.

Book-Binding; the art of sewing together the sheets of a book, and securing them with a back and strong pasteboard sides, covered with leather, &c. Binding is distinguished from *stitching*, as in the latter the leaves are only sewed, without bands or backs.

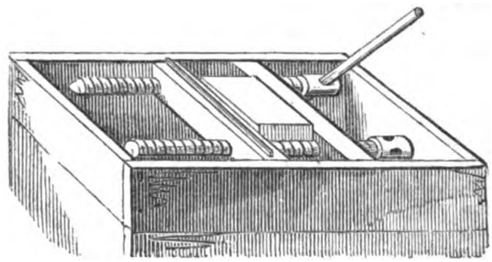
The first operation is, to fold the sheets according to the size of the book, that is, two leaves for folios, four for quartos, eight for octavos, &c., which the workwomen do with a slip of ivory or box, called a folding-stick; in this they are directed by the catchwords and signatures, which are the letters with the numbers annexed to them, at the bottom of the pages. The leaves thus folded, and laid over each other in the order of the signatures, are beaten on a stone with a heavy hammer to make them solid and smooth, and then pressed. Being thus prepared, they are sewed in a sewing-press, upon packthreads or cords, which are called bands, at a proper distance from each other, and in a convenient number; which is done by drawing a thread through the middle of each sheet, and giving it a turn round each band, beginning with the first, and proceeding to the last. The common number of bands is, six in folios, and five in quartos, octavos, &c. Sometimes they use a saw to make places for the bands, which are sunk into the paper, so that the back of the book, when bound, may be smooth, without any appearance of bands. After this the backs are glued, the ends of the backs being opened, and scraped with a knife, for the more convenient fixing of the pasteboards; then the back is turned with a hammer, the book being fixed in a press between boards, called backing boards, in order to make a groove for admitting the pasteboards. The boards being then applied, holes are made for drawing the bands through, the superfluous ends being cut off, and the parts hammered smooth. Then the book is pressed in order for cutting; which is performed by a particular machine called a plough,



to which is fixed a knife, *a*. After this the book is put into a press called the cutting-press, betwixt two boards, the one lying even with the press, for the knife to run upon; the other above it for the knife to cut against.

Now, very much of the success of this operation depends on the form of the knife *a*, and the quality of the steel. If it be very obtuse, then it cuts irregularly, and the steel should be of the best kind of a straw coloured temper. To diminish the danger of breaking, it may be advisable to make the back of the blade of iron.

The cutting frame is shown in the figure beneath.



The book being cut, the pasteboards are squared with a proper pair of iron shears; and it is then ready for sprinkling, gilding, blacking, or marbling the leaves. The colours with which it is sprinkled are usually vermillion, or sap-green; which is done with a brush made with hogs' bristles, holding the brush in one hand, and striking the hair with the other.

A patent was obtained in 1800 by Mr. Palmer, for an improvement in the mode of binding books, particularly account books for merchants. This consists in the addition of a certain metallic chain which is made or applied in the following manner: First provide several small bars of metal, about the thickness of a shilling, or more, according to the size and thickness of the book; the length of each bar being from half an inch to several inches long, in proportion to the strength required in the back of the book. At each end of every bar is made a pivot of different lengths, in proportion to the thickness of two links, which they are to receive. Each link is made in an oval form, and contains two holes, proportioned to the sizes of the pivots; and these links are of the same metal as the hinge, each of them being nearly equal in length to the width of two bars. The links are then rivetted on the pivots, each pivot receiving two of them, and thus holding the hinge together, on the principle of a link-chain or hinge. There are farther, two holes or more of different sizes, as required in each bar of the hinge or chain, by means of which each section of the book is strongly fastened to it; and the hinge so fastened, operates with the back of the book, when bound, so as to occasion the several sections to open freely and admit the ruled lines being written into, without any inconvenience, close to the back.

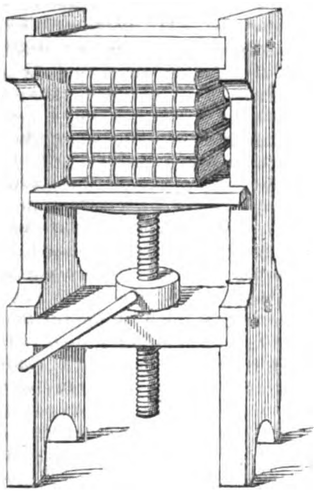
We may now suppose the book prepared for gilding; and, being put tight into the press between two boards, it is scraped with a knife called a scraper; and after that, with another, called a smoother, in order to take out all scratches. Being thus made smooth, it is prepared with a little adhesive mixture: the gold is then laid upon it, and afterwards dried before the fire. When dried, it is burnished off. Blacking the leaves is done with fine antimony rubbed upon them until quite dry, when it is burnished like the gold.

The head-band is now added, which is an ornament of thread or silk, of two or three colours, placed at each extreme of the book, across the leaves, and woven or twisted, sometimes about a single, and sometimes a double piece of rolled paper, or, what is more lasting, of glued paper thread.

When leather is employed, it is first moistened in water, then cut to the size of the book, and the thick-

ness of the edges pared off on a marble stone kept for that purpose. The cover is next coated with paste, made of wheat flour; then stretched over the pasteboard on the outside, and doubled over the edges withinside.

The next step is, to place the book firmly between two boards, to make the cover adhere the stronger to the pasteboards and the back; on the exact performance of which depends a great part of the neatness of the work. The back is then warmed at the fire to soften the glue, and the leather of the back is rubbed on with a folding-stick, to fix it close to the back of the book. It is now placed to dry, and finished. Two blank leaves, on each side, are then to be pasted down to the cover; and, when dry, the leaves are burnished in the press, and the cover rolled on the edges.



The press commonly used for the purpose is shown in the annexed figure. But when a very high relief is required, or great power in the apparatus, then the hydraulic press of Bramah is employed. See HYDROSTATICS.

The cover is now glazed twice with the white of an egg; it is then filletted, plain, or with gold; and at last polished with a polishing iron, passed hot over the glazed cover. If the book be required to be lettered, they sometimes paste pieces of leather for the purpose on the back.

BOOK-KEEPING is a mercantile term used to denote the method of keeping commercial accounts, of all kinds, in such a manner, that a man may thereby know, at any time, the true state of his affairs, with clearness and expedition. Book-keeping is divided into *single*, and *double*, or Italian book-keeping. In the first, the posts of debtor and creditor are separated from each other, and entered in such a way, that each one appears singly; while, in the latter, creditor and debtor are in continual mutual connection, to which end all the posts are entered doubly,—once on the debtor, and once on the creditor side, by which every error or mistake is prevented. This mode of double book-keeping originated in Italy, in the 15th century; yet it had been practised in Spain in the 14th century. The principle of this system is, that all money and articles received become debtors to him from whom they are received, and, on the other hand, all those who receive money or goods in return become debtors to cash or to the goods. The books which the merchant wants are principally, a *waste-book*, in which all his dealings are recorded without particular order; a *journal*, in which the contents of the waste-book are separated every month, and entered on the debtor and creditor sides; and a *ledger*, in which the posts entered in the journal are placed under particular accounts, and from which, every year, the balance is drawn.

BOOMS are long poles employed in extending the sails of a ship. Of these there are several kinds, according to the purposes for which they are intended. Booms, simply so called, are those employed in extending the lower sails when the ship is going large; which is done by putting one end of the boom into the clue of the sail, and the other end to a butt against the side of the ship. These booms are retained in their proper positions by means of ropes called guys.

BOÖTES; a northern constellation, called, also, by the Greeks, *Arctophylax*, and, by the English, *Charles's Wain*. Arcturus was placed, by the ancients, on his breast; by the moderns, on the skirt of his coat. Fable relates that Philomelus, son of Ceres and Jason, having been robbed by his brother Plutus, invented the plough, yoked two bulls to it, and thus supported himself by cultivating the ground. Ceres, to reward his ingenuity, transferred him, with his cattle, under the name of *Boötes*, to the heavens.

BOOTY, in *Military* affairs; the moveables taken from an enemy in war.

BORACIC ACID, uncombined, exists in several small lakes in Tuscany, at Volcano, one of the Lipari islands, and in the hot springs near Sasso, in the Florentine territory, from whose waters it is deposited by natural evaporation. It is easily obtained also from borax, a native salt, composed of this acid and soda, by dissolving it in boiling water, and gradually adding sulphuric acid to disengage the soda: the boracic acid is in this manner set at liberty, and is deposited in crystals on the cooling of the liquid: these, when washed with cold water and dried, are perfectly pure. In this state, it presents the form of brilliant, white, hexagonal scales, soft and greasy to the touch, and having a specific gravity of 1.479. Its taste, when first taken into the mouth, is sourish; afterwards it becomes bitter, and finally leaves a sweetish impression upon the tongue. It is slightly soluble in water, and much more so in alcohol, to which, when burning, it communicates a green colour. It contains 43 per cent. of water, which it parts with, on being heated to redness, when it melts into a transparent glass, and is called *calcined boracic acid*. Boracic acid was discovered by Sir Humphry Davy to be a compound of a peculiar base, which he called *boron*, and oxygen, in the proportion of 8 parts of the former to 16 of the latter. Its principles are separable both by means of galvanism and by the action of potassium. Boron is a tasteless and inodorous substance, in the form of a greenish-brown powder. It is insoluble in water, ether, alcohol, and oils; nor does it fuse when subjected to the strongest heats. By exposure to common air, it gradually becomes oxygenated, and, when heated in oxygen gas, burns vividly, and is converted into boracic acid.—Boracic acid is sometimes employed in the analysis of minerals; and, since its discovery in such abundance in the Italian springs and lakes, it has also been used in the manufacture of borax, being united with soda.—The most important combination formed by boracic acid is that with soda, commonly called *borax*. It is brought into Europe, in an impure state, from the East Indies, under the name of *tincal*, and is understood to occur principally in certain lakes, from whence it is obtained by evaporation. It is also reported to be dug from the earth in Thibet, and to

exist in the mines of Riquintipa and Escapa, in South America. A knowledge of its manufacture was, for a long time, confined to the Venetians and Hollanders. This is now known to consist in boiling carbonate of soda with the calcined tincal, in order to saturate its excess of acid: 12 pounds of carbonate of soda are requisite for every 100 pounds of washed tincal, in the water: the ley is left to cool gradually and crystallize. The French nation manufacture their borax (of which they consume about 25 tons annually) from the boracic acid found in the Italian lakes; in consequence of which the price of this article has fallen in France from five shillings and ten pence the pound, to two shillings and two pence. The process which they adopt is to dissolve 1200 pounds of carbonate of soda in 1000 pounds of water, to which is added, by 20 pounds at a time, 600 pounds of Tuscan boracic acid. This is done in a leaden boiler, of double the capacity requisite to contain the materials, in order to provide for the effervescence which takes place. The heat is kept up for 30 hours, when the clean liquid is drawn off into leaden coolers, a foot in depth, where the first crop of crystals deposits itself in three days. 100 pounds of the best Tuscan boracic acid prdduce about 150 of borax.—Borax appears in crystalline masses of a moderate size, or in distinct hexagonal prisms, terminated by three or six-sided pyramids; is of a white colour, and transparent. It requires 20 parts of cold and 6 of boiling water for its solution. Exposed to heat, it swells up, boils, loses its water of crystallization, and becomes converted into a porous, white, opaque mass, commonly called *calcined borax*. A stronger heat brings it to the form of a vitreous transparent substance, in which state it is known under the name of *glass of borax*. Borax forms one of the best fluxes known. It is used in the analysis of minerals by the blow-pipe, in melting the precious metals, in forming artificial gems, and in soldering.—Another native combination of boracic acid is that with magnesia, known in mineralogy under the name of *boracite*. It is found in small crystals, imbedded in gypsum, near Lunenburg, in Lower Saxony, and at Segebore, in Holstein. Their form is that of a cube, with the edges and four of the solid angles truncated. They are remarkable for their electric properties, becoming, when heated, negatively electrified at their perfect angles, and positively so at their truncated angles.

Borax, see Boracic Acid.

Bordure, or Border, in *Heraldry*, is a partition ıne running all round the inside of the field, of an equal width, taking up one-fifth from the outer edge of the field, and without any shadow.

Boreal; northern.

Boring is a species of circular cutting, in which a cylindrical portion of a substance is gradually removed. When tubes of metal are to be formed, a cast is, in some cases, made in solid metal, and the whole of the bore is produced by the boring machine: in others, the cast is made hollow at first, and the borer is only used to give uniformity and finish to the inside of the tube. In boring cannon, the tool is at rest while the cannon revolves. By this arrangement the bore is formed with more accuracy than by the old method of putting the borer in motion. The tool is kept pressed against the cannon by a regular force. Cylinders of steam-engines are cast hollow, and afterwards bored; but, in this case, the borer revolves, and the cylinder remains at rest. In either case, the axis of the borer and that of the cylindrical material should coincide; for otherwise, if the borer revolve, it will perforate obliquely; if the material revolve, the perforation will be conical. The instruments used are gimblets, augers, centrebits, drills, &c. Drills are made to turn rapidly, either in one direction by means of a lathe-wheel and pulley, or alternately in opposite directions by a spiral cord, which coils and uncoils itself successively upon the drill, and is aided by a weight or fly.—*Boring for water* has been, of late, successfully employed in obtaining a supply without sinking a well. In the progress of the boring, frequent veins of water are passed through, but the operation should be continued until a main spring is struck, which, if from a sufficiently elevated source, will flow up to the surface; otherwise a well must be sunk to the level of the source, and the water must be raised by a pump. To exclude mineral waters, land-springs, &c., the hole is generally cased with a metallic pipe. See Water.

Bossage, in *Architecture*; a projecting stone which is intended to be sculptured. Also rustic work which projects from the plain face of the masonry.

Boudoir; a small room, simply and gracefully fitted up, destined for retirement.

Boutant, in *Architecture*. An arc boutant is an arch or buttress, serving to sustain a vault; and which is itself sustained bv some strong wall, or massive pile.

Bow; the name oı one of the most ancient and universal weapons of offence. It is made of steel, wood, horn, or other elastic substance, which, after being bent by means of a string fastened to its two ends, in returning to its natural state, throws out an arrow with great force. The figure of the bow is nearly the same in all countries, having generally two inflexions, between which, in the place where the arrow is fixed, is a right line. The Grecian bow was nearly in the form of the letter Σ: in drawing it, the hand was brought back to the right breast, and not to the ear. The Scythian bow was distinguished for its remarkable curvature, which was nearly semi-circular; that of the modern Tartars is similar to it. The materials of bows have been different in different countries. The Persians and Indians made them of reeds. The Lycian bows were made of the cornel-tree; those of the Ethiopians, of the palm-tree. That of Pandarus (Il. iv. 104) was made from the horn of a mountain goat, 16 palms in length: the string was an ox-hide thong. The horn of the antelope is still used for the same purpose in the East. The long-bow was the favourite national weapon in England. The battles of Cressy (1346), Poictiers (1356), and Agincourt (1415), were won by this weapon. It was made of yew, ash, &c., of the height of the archer. The arrow being usually half the length of the bow, the *cloth-yard* was only employed by a man six feet high. The arbalist, or cross-bow, was a popular weapon with the Italians, and was introduced into England in the 13th century. The arrows shot from it were called *quarrels*. The *bolt* was used with both kinds of bows. Of the power of the bow, and the distance to which it will carry, some remarkable anecdotes are related. Xenophon mentions an Arcadian whose head was shot through by a Carduchian archer. Stuart mentions a random shot of a Turk, which he found to be 584

yards; and Mr. Strutt saw the Turkish ambassador shoot 480 yards in the old archery ground in London. An old author speaks of a Turkish bow which was known to pierce a steel target, or a piece of brass, two inches thick. In the journal of king Edward VI. it is mentioned, that 100 archers of the king's guard shot at an inch board, and that some of the arrows passed through this and into another board behind it, although the wood was extremely solid and firm. It has been the custom of many savage nations to poison their arrows. This practice is mentioned by Homer and the ancient historians; and we have many similar accounts of modern travellers and navigators from almost every part of the world. Some of these stories are of doubtful authority, but others are well authenticated. Some poison, obtained by Condamine from South American savages, produced instantaneous death in animals inoculated with it. The poisoned arrows used in Guiana are not shot from a bow, but blown through a tube. They are made of the hard substance of the cokarito-tree, and are about a foot long, and of the size of a knitting-kneedle. One end is sharply pointed, and dipped in the poison of woorai: the other is adjusted to the cavity of the reed, from which it is to be blown, by a roll of cotton. The reed is several feet in length. A single effort of the breath carries the arrow 30 or 40 yards.

Bow, in *Music*, is the name of that well known implement by the means of which the tone is produced from viols, violins, and other instruments of that kind. It is made of a thin staff of elastic wood, tapering slightly till it reaches the lower end, to which the hairs (about 80 or 100 horse-hairs) are fastened, and with which the bow is strung. At the upper end is an ornamented piece of wood or ivory, called the *nut*, and fastened with a screw, which serves to regulate the tension of the hairs. It is evident that the size and construction of the bow must correspond with the size of the species of viol instruments from which the tone is to be produced.

Bow, in *Architecture;* a circular end to a church, a room, or building.

Bow Instruments are all the instruments strung with cat-gut or goat-gut, from which the tones are produced by means of the bow. The most usual are the double bass *(violono* or *contrabasso);* the small bass, or *violoncello;* the tenor *(viola di braccio);* and the violin proper *(violino,* from *violon).* In reference to their construction, the several parts are alike: the difference is in the size. See Violin and Quartett.

Bowsprit; a large boom or sprit projecting from the bow of a ship, over the stern, and hence its name.

Braced, in *Heraldry,* is used in speaking of chevronels which are intermingled.

Brachium, the arm, in *Anatomy,* is that part of the upper extremity which intervenes between the joints of the shoulder and elbow.

Bracket, in *Architecture;* a small support against a wall for a figure, lamp, clock, &c., which are susceptible of considerable elegance of design and decoration.

Bracteates; thin coins of gold or silver, with irregular figures on them, stamped upon one surface only, so that the impression appears raised on one side, while the other appears hollow. It seems most probable that these coins, being circulated in great quantities under Otho I., emperor of Germany, when the working of the silver mines of the Hartz afforded the most convenient medium of exchange, were first coined at that place, and spread into other countries, where the Roman money was not known or in circulation. The original form of these coins was borrowed from that of the Byzantian gold ones, which, about that time, lost in thickness what they had gained in extension. Allowance was made, however, for the greater softness of the silver. Gold and copper *bracteates* belong only to a later period. The name *bracteate* itself points to Byzantium (according to Isidore, it is derived from βραχεῖν, to ring). *Bractea* signifies leaf of gold, or other metal. The real name, at the time when they were in circulation, was *denarius, moneta, obolus, panningus.* They are of importance as illustrating history. A very good representation of a rich collection of *bracteates* can be seen in W. G. Becker's *Two Hundred Rare Coins of the Middle Ages* (Dresden, 1813, 4to.) In later times, there have been many bad imitations of these coins, and the study of them is therefore much more difficult. *Bracteated coins,* or *bracteati nummi,* a term used to signify coins or medals covered over with a thin plate of some richer metal. They are usually made of iron, copper, or brass, plated over and edged with gold or silver leaf. Some of them are to be found even among the truly ancient coins. The French call them *fourrées.*

Brails; certain ropes passing through pulleys on the mizzen-mast, and afterwards fastened, in different places, on the hinder edge of the sail, in order to draw it up to the mast, as occasion requires. *Brails* is likewise a name given to all the ropes employed to haul up the bottoms, lower corners, and skirts of the great sails in general. The operation of drawing them together is called *brailing* them up, or hauling them up to the *brails.*

Brain. The brain is a soft substance, partly reddish-gray, and partly whitish, situated in the skull, penetrated by numerous veins, and invested by several membranes. Democritus and Anaxagoras dissected this organ almost 3000 years ago. Haller, Vicq d'Azir, and other anatomists in modern times, have also dissected and investigated it without exhausting the subject. Between the skull and the substance of the brain three membranes are found. The outer one is called the *dura mater.* This is strong, dense, and elastic. It invests and supports the brain. The next which occurs is the *tunica arachnoidea.* This is of a pale white colour, yet in some degree transparent, very thin, and, in a healthy state, exhibits no appearance of vessels. The membrane below this is called the *pia mater.* It covers the whole surface of the brain. It is very vascular, and a great portion of the blood which the brain receives is spread out upon its surface in minute vessels. The brain consists of two principal parts, connected by delicate veins and fibres. The larger portion, the *cerebrum,* occupies, in men, the upper part of the head, and is seven or eight times larger than the other, the *cerebellum,* lying behind and below it. It rests on the bones which form the cavities of the eyes, the bottom of the skull and the *tentorium,* and projects behind over the *cerebellum.* On the whole exterior of the *cerebrum* there are convolutions, resembling the windings of the small intestines. The external reddish substance of the brain is soft and vascular, and is called the *cortical* substance; the internal is white, and is called the *medullary* sub-

stance of the brain. This *medulla* consists of fibres, which are very different in different parts. The *cerebellum* lies below the *cerebrum*, in a peculiar cavity of the skull. By examining the surface, it is seen to be divided into a right and left lobe, by the spinal marrow lying between, but connected at the top and bottom. Like the *cerebrum*, it is surrounded by a vascular membrane, reddish-gray on the outside, and composed of a medullary substance within. In proportion to its size, also, it has a more extensive surface, and more of the vascular membrane, than the *cerebrum*. In a horizontal section of it, we find parallel curved portions of the cortical and the medullary substances alternating with each other. Between the cortical and the medullary substance, there is always found, in the *cerebellum*, a third intermediate yellow substance. All the *medulla* of the *cerebellum* is also united in the middle by a thick cord. Experience teaches that, in the structure of the brain, irregularities are far more uncommon than in other parts of the human body. It is worthy of observation, that every part of the brain is exactly symmetrical with the part opposite. Even those which lie in the middle, and are apparently single (the spinal marrow, for instance) consist, in fact, of two symmetrical portions. The total weight of the human brain is estimated at two or three pounds. It is larger and heavier in proportion to the youth of the subject; and in old age it becomes specifically lighter. In delirious affections, it is sometimes harder and sometimes less solid and softer. The brain is the organ of sensation, and consequently the material representative of the soul, and the noblest organ of the body. See PHRENOLOGY.

BRANCH, in *Anatomy;* a division of a vein, artery, or nerve. All the veins of the body are only branches of the vena cava.

BRANDY. This valuable spirit is produced by the distillation of wines of all kinds, and, properly speaking, by no other fermented liquor whatever. It is prepared in many of the wine countries of Europe, and with particular excellence in many parts of the centre and south of France. The necessary process is extremely simple, being nothing more than a well-regulated distillation of wine without addition, from suitable vessels; but to alter or improve the colour and flavour, various substances are added to the spirit after distillation. Though every wine will give a certain portion of brandy by distillation, some are much preferable to others. In general, the strong heavy wines yield the most spirit, whilst some of the light thin wines furnish no more than about a fifteenth. If the quantity is less than a sixth, it will hardly repay the expense of distillation.

The distilling apparatus is composed of three parts, the *alembic* or boiler, the *capital* which fits on the top of the boiler to receive the spirituous vapour, and the *serpentine* or *worm*, a convoluted pipe fitting to the beak of the alembic, and immersed in a large tub of water to cool the vapour of the spirit, and condense it into a liquor, which flows out at the bottom. See DISTILLATION and ALCOHOL.

BRASS. This very important alloy is a mixture of copper and zinc in various proportions, so intimately united as to form a homogeneous malleable yellow metal, applicable to a vast variety of purposes, and capable of being wrought with the greatest facility.

It is not easy to obtain a perfect union of zinc and copper by mere fusion in open vessels; for at a heat less than is required to melt the copper, the zinc readily takes fire, and much of it burns off before it has time to mix with the other metal, so that the proportion of zinc is constantly lessening by volatilization. Even after both metals are fused, the zinc continues to burn off in uncovered vessels, and at last scarcely any thing but copper would be left. In order, therefore, to combine copper most intimately with zinc, and yet to preserve its malleability, the ingenious process of cementation has been resorted to in the manufacture of brass, which is performed by heating in a covered pot alternate layers of copper in small pieces, with zinc and charcoal, and continuing the fire till the copper is thoroughly impregnated with the zinc.

Zinc being a volatile metal, can only be procured from its ores by sublimation; the process for obtaining it being to heat a mixture of its ore with charcoal in a vessel closed on all sides, except where it admits a tube, the lower end of which dips in water: as soon as the charcoal reduces the oxide, the metal rises in vapour through the tube, and condenses in the water below. A similar reduction takes place in brass-making, only the vapour of the zinc, instead of being conveyed out of the crucible in which it is formed, unites with the copper enclosed in the same vessel, and the whole melts down into brass. A less heat is required in brass-making than that which fuses copper, the zinc being able to penetrate the copper when thoroughly red hot, and melting it down as soon as it becomes brass.

BRAVURA AIR; an air so composed as to enable the singer to show his skill in execution by the addition of embellishments, striking cadences, &c. It is sometimes used for the style of execution.

BREACH; the aperture or passage made in the wall of any fortified place, by the ordnance of the besiegers, for the purpose of entering the fortress. They should be made where there is the least defence, that is, in the front or face of the bastions. In order to divide the resistance of the besieged, breaches are commonly made at once in the faces of the attacked bastions, and in the ravelin. This is effected by battering, and, at such places as the cannon do not reach, by the aid of mines. The breach is called *practicable*, if it is large enough to afford a reasonable hope of success in case of an assault. This is generally considered to be the case if it allows a passage to 14 men abreast. Frequently, however, a breach of much less extent, even of half that width, may be entered.

BREAD. In the earliest antiquity, we find the flour or meal of grain used as food. The inconvenience attending the use of the grain in its natural state, and, perhaps, the accidental observation, that, when bruised, and softened in water, it formed a paste, and, when dried again, a more compact, mealy substance, led, by degrees, to the artificial preparation of bread. Easy as it seems to us, it must have been a long time before it was completely successful. The grain was first bruised between stones, and, from the meal mixed with milk and water, a dry, tough, and indigestible paste was made into balls. This is yet the chief food of the caravans in the deserts of Northern Africa. The Carthaginians, also, ate no bread, and hence were called, in derision, by the Romans, *pultiphagi* (pottage-eaters). After many attempts, or, perhaps, accidentally, it was observed that, by bringing the paste into a state

of fermentation, its tenacity was almost entirely destroyed, and the mass became bread, porous, agreeable to the taste, digestible, and, consequently, healthy. The process formerly pursued may be thus described:—Some old dough, called *leaven*, which, by a peculiar fermentation, has swelled up, become spongy, and acquired an acid and spirituous smell, is kneaded with the new dough, and produces, though in an inferior degree, a similar fermentation in the whole mass. The whole thus becomes spongy; a quantity of air or gas is developed, which, being prevented from escaping by the tenacity of the dough, heaves and swells it, and gives it a porous consistency. This is called the *working* of the dough. In this state, the dough is put into the heated oven, where the air contained in it, and the spirituous substance, are still more expanded by heat, and increase the porosity of the bread, making it materially different from the unbaked dough. In some parts of Sweden, the bread is composed, in part, of the bark of trees, during the winter. In Westphalia, a kind of very coarse, black bread is made, of which the peasants bake one large loaf for the whole week. This is divided for use with small saws. It is called *pumpernickel*, and is sometimes exported. In many parts of Germany, bread is made of grain nearly entire, or but just bruised, which is very coarse, and frequently forms part of the food of the horses. Bread is found wherever civilization has extended. The want of bread has often occasioned public commotions, particularly in Paris and ancient Rome.

The superior nutritious qualities of bread have been doubted; but the question has been set at rest in France, by some chemical researches into the proportional nutriment of various edible substances.

MM. Percy and Vauquelin were appointed to make the experiments on which the solution of these questions rested, and they have published the results in an interesting report on domestic economy. They have ascertained that bread contains 80 nutritive parts in 100; meal 34 in 100; French beans, less; common beans, peas, and lentils, still less; cabbages and turnips, the most aqueous of all the vegetables compared, produce only eight pounds of solid matter in 100 pounds; carrots and spinach produce 14 in the same quantity; whilst 100 pounds of potatoes contain 25 pounds of dry substance. It must be recollected, that the solid parts, when separated from the aqueous or humid parts, may contain a small quantity of extractive or ligneous matter probably unfit for food; and next, that the same substances do not act uniformly on all stomachs, and are relatively more or less nutritious. But as a general result, the learned reporters estimate that one pound of good bread is equal to two pounds and a half or three pounds of potatoes; that 75 pounds of bread and 30 of meat, may be substituted for 300 pounds of potatoes. The other substances bear the following proportions: four parts of cabbage to one of potatoes; three parts of turnips to one of potatoes; two parts of carrots and spinach to one of potatoes; and about three parts and a half of potatoes to one of rice, lentils, beans, French beans, and dry peas.

Where a family grow their own corn, they may be certain of its purity. Its goodness, as a mere article of trade, is measured by the comparative smallness of the quantity of bran which it produces. This, indeed, in family economy, is not of high importance; but if it is wished to make a distinction, then select such wheat as is round and plump, rejecting that which is shrivelled as yielding most bran. Where plump and shrivelled grains are found together in the same binn, they may be separated by simple immersion in water. If the grain be all sound and of equal quality, the smallest grains will still be proportionably the lightest, and will swim whilst the others fall to the bottom; and should a very strict separation be wished for, that may be produced by a judicious application of weak brine, which being gradually poured in, so as to increase the specific gravity of the water, the lighter grains will proportionably rise: this, however, must be stopped in time, otherwise the water will be so impregnated with salt that the whole of the grain will rise to the surface.

If the grain is dried immediately afterwards, it will not receive any damage from the experiment. Should the whole of the harvesting appear at first sight to be damaged, it is not on that account to be absolutely rejected. A gentleman of considerable science and experience has communicated to the Royal Society a process for sweetening musty corn, by simply immersing it in boiling water, and letting it remain till cold. The quantity of water should be double that of the corn to be purified. He has found that the musty quality rarely penetrates through the husk of the wheat, and that in the very worst cases it does not extend beyond the amylaceous matter immediately under the skin. In the hot water all the decayed or rotten grain swims on the surface, so that the remaining wheat is effectually cleaned from all impurities, and without any material loss. The wheat must afterwards be dried and occasionally stirred on the kiln, when it will be found improved to a degree scarcely credible without actual experience.

The first adulteration may be suspected to take place at the mill; but even this, with a little care, may be guarded against by an expense, at first, of about five guineas for a portable mill, which will grind any kind of grain with little comparative trouble.

This species of portable mill was originally constructed for the purpose of supplying the French armies with flour, during their march to Moscow; in the course of which service its merits were fully proved. It was brought from Paris by Sir John Sinclair, and presented by him to the Society of Arts, by whom it is considered one of the most useful machines ever submitted to the notice of that scientific body. With the power of one man it will grind about a bushel of wheat in two hours, and as the labour is not severe, he may grind from four to five bushels per day. It will last for many years, and is not liable to go wrong: the only precautions required in the use of it are, not to turn it above twenty revolutions a minute, as even in that case it would heat (sixteen or seventeen revolutions are as many as is necessary); not to allow the handle to be turned when the mill is empty; and to prevent pieces of iron or hard stone from getting into it. The corn should be dry, or otherwise it would clog the plates, which would make it necessary to take the mill to pieces to clear them. It can easily be attached to any power, either of horses, steam, or water.

People in the flour trade generally knead a small quantity by way of experiment; if good, it immediately forms an adhesive, elastic paste, which will

readily assume any form that may be given to it, without danger of breaking: pure and unadulterated flour may likewise be easily distinguished by other methods. Seize a handful briskly, and squeeze it half a minute; it preserves the form of the cavity of the hand in one piece, although it may be roughly placed on the table. Not so that which contains foreign substances: it breaks in pieces more or less—that mixed with whiting being the most adhesive, but still dividing and falling down in a little time. Flour mixed with ground stones, bones, or plaster of Paris, loses its form at once, and the more bran there may be in it, the sooner will it drop to pieces. It may also be observed, that genuine flour will longer keep the impression even of the cuticle of the skin, than that which is adulterated, the latter very soon throwing up the fine marks.

The admixture of fine pulverised clay in the prime necessary of life, is likewise a practice in many parts of the kingdom; and that in one or two instances, to a very great extent: the industrious adulterators thinking, perhaps, that the white or Cornwall clay might be equal in its nutritious qualities to the German clay, which was thus described some years ago in a German Ephemeris:

"In the lordship of Moscaw, in the Upper Lusatia, a sort of white earth is found, of which the poor, urged thereto no doubt by the calamities of the war in those parts, actually made bread. It is taken out of a hill where they formerly worked saltpetre: when the sun has somewhat warmed this earth, it cracks, and small white globules proceed from it as meal; it does not ferment alone, but only when mixed up with meal. M. Sarlitz, a Saxon gentleman, was pleased to inform us, that he has seen persons who, in a great measure, lived upon it for some time. He assures us, that he procured bread to be made of this earth alone, and of different mixtures of earth and meal, and that he even kept some of this bread by him upwards of six years: he farther says, a Spaniard told him that this earth is also found near Gironne in Catalonia."

As the economical housewife will assiduously avoid the use of alum in her bread, so must she shun all other chemical adulterations, except in cases where the flour to be used is unavoidably musty, or where it is new flour after a wet season, when the bread often comes out of the oven with an unpleasant heaviness about it, which may induce families to give up their own wholesome home-baked, for the produce of some *scientific* baker. The evil spoken of has been obviated by the carbonate of magnesia, but the best remedy is the carbonate of ammonia. If the flour be not very unsound, for 14lbs. of it, use one ounce of carbonate of ammonia, taking particular care to purchase where you can rely upon having it *pure*, as much depends on this. This ounce of carbonate of ammonia should be dissolved in a little warm water, and then put into such farther quantity of water as may be requisite for kneading the dough quite stiff. As this carbonate is volatile, there is no great impropriety in increasing the quantity. It is generally used by bakers and confectioners. In case the flour be very bad, it might be well to make the experiment with 7lbs. of it, as a much larger quantity of the ammonia would be needful; but the very worst of flour may be rendered useable if sufficient of the carbonate of ammonia be introduced. When purchased, the ammonia should be tightly corked up in a phial, in order to prevent the escape of ammoniacal gas, to which it is liable. An ounce of carbonate of ammonia costs less than the same quantity of carbonated soda.

A considerable increase in home-made bread, even equal to one-fifth, may be produced by using bran water for kneading the dough. The proportion is three pounds of bran for every twenty-eight pounds of flour, to be boiled for an hour, and then strained through a hair sieve. The bran need not then be lost, but mixed up with dry food for the poultry yard.

In baking bread at home there are many experiments that may be tried for amusement as well as utility. One mode was formerly actually practised generally in the county of Essex, even so late as the 16th century, and was as follows:—Take peeled turnips; boil them until they are soft; press out the juice and mix them, beaten very fine and small, in their own weight of wheat or flour; add salt dissolved in warm water; knead the whole like other dough, and bake it.

Excellent paste for meat or fruit pies may be made with two-thirds of wheat flour, one-third of the flour of boiled potatoes, and some butter or dripping; the whole being brought to a proper consistence with warm water, and a small quantity of yeast added where lightness is particularly wished for.

This will also make very pleasant cakes for breakfast; and may be made with or without spices, fruit, &c.

Mr. Whately, of Cork, received a gold medal in the year 1813, from the Society for the Encouragement of Arts and Sciences, for a machine for the expeditious rasping of potatoes, and for his experiments in making bread with the farina of them. The bad harvest in 1816 having turned his attention to theoretical improvements, he thus expresses himself on the subject:—"Having by me a considerable quantity of the former, which I had prepared in the year 1813, I began to use it in bread, and find that it has not only very much improved from age, by losing the strong flavour of the raw potatoe, which it retains when recently made, but that it serves to render the flour made from the wheat of last season more palatable. The proportion that I make use of is one-fourth; which has the effect of making the bread lighter, drier, and beyond comparison better than the bread made from the wheaten flour alone of the last crop; and I can safely and strongly recommend its adoption to all those who find bread from new flour heavy, glutinous, and difficult in the preparation. It should be remarked, that the farina I am using was made at a late period of the spring and early in the summer of 1813, after a considerable vegetation had commenced in the potatoes; consequently, it is neither so good nor so profitable as if it had been made before the vegetative process began. The best time for making it is during the first three or four months after the potatoes have been dug from the ground; and although they yield farina to a very late period of the year, it is neither so nutritive in quality, nor so great in quantity, as when it is made at an earlier period. The experiment proves how extremely advantageous it would be for the public, in years when the crop of potatoes is very abundant, to convert a portion of it into farina; which, experience proves, when properly dried, will keep good for almost an indefinite length of time. In such seasons, the farina

which is about one-seventh part of the potatoe, would be produced at about two-pence halfpenny or three-pence per pound.

"It might remain stored up in casks until the seasons called for its use, and become a very great and profitable resource in times of scarcity. Indeed, from the peculiar quality that it possesses, of continuing for years to afford its nutritive properties, not merely uninjured, but really improved by age, I know of no article of food which can, with such advantage be furnished from the bounties of Providence in one season, to administer to the wants of another. It offers such strong inducement in this respect to speculative men, that I shall hope hereafter, in an unproductive year, to see very great relief afforded from it.

"The manufacturer has only to prepare it after the manner of starch at those times when the price indicates a very plentiful supply of potatoes, and to preserve it in his warehouse until a sufficiently tempting price calls it forth, greatly to his own advantage, and to that of the public. Perhaps it is not unreasonable to calculate, that every seventh year would give him the opportunity of doubling or trebling capital thus employed; and I consider it would be well worth the attention of any speculative individual, residing in a country where potatoes are cheap and distant from market, to put this experiment in practice upon a large scale." An account of this process, which is very simple, and an engraving of the machine, may be seen in the volume of the *Transactions of the Society of Arts* for that year.

Breakers; billows which break violently over rocks lying under the surface of the sea. They are readily distinguished by the foam which they produce, and by a peculiar hoarse roaring, very different from that of waves in deep water. When a ship is driven among breakers, it is hardly possible to save her, as every billow that heaves her upward serves to dash her down with additional force.

Breaking Bulk; the act of beginning to unlade a ship, or of discharging the first part of the cargo.

Breakwater. See Cherbourg and Plymouth, in our second division.

Breast. See Chest.

Breast-Plate; a piece of defensive armour, covering the breast, originally made of thongs, cords, leather, &c. (hence *lorica, cuirass*), but afterwards of brass, iron, or other metals. It may be considered as an improvement of the shield or buckler, which was borne on the left arm, and moved so as to protect, successively, all parts of the body. It being perceived that the free use of both hands in the employment of offensive weapons was important, the defensive armour was attached to the body, and received different names from its position, use, &c.; as, for instance, breast-plate, cuisses, greaves. These different species of defensive armour are of little use against fire-arms, and have, therefore, generally fallen into disuse in modern war. *Breast-plate*, in Jewish antiquity, was a folded piece of rich, embroidered stuff, worn by the high-priest. It was set with twelve precious stones, bearing the names of the tribes. It was also called the *breast-plate of judgment*, because it contained the Urim and Thummim.

Breast-Wheel; a water-wheel which receives the water at about half its height, or at the level of its axis. In England, float-boards are employed, which are fitted accurately to the mill-course, so that the water, after acting on the floats by its impulse, is detained in the course, and acts by its weight. In small mills they are often constructed with buckets, and with a part of the circumference fitted to the mill-course.

Breast-Work, in the *Military Art;* every elevation made for protection against the shot of the enemy. Wood and stone are not suitable for breast-works, on account of their liability to splinter. The best are made of earth; in some circumstances, of fascines, dung, gabions, bags of sand, and of wool. The thickness of the work must be in proportion to the artillery of the enemy. In general, it ought not to be less than 10, nor more than 18, or, at most, 24 feet thick. The rule of Cugnot is, that the breast-work should be so high, that nothing but the sky and the tops of trees can be seen within cannon shot from the interior of the intrenchments. If this rule cannot be followed, on account of the height of neighbouring mountains, the interior of the fortification ought to be secured by traverses.

Breath; the air which issues from the lungs, during respiration, through the nose and mouth. This operation is performed without effort, but still it causes a motion in the external air, before the nose and mouth. The air expired is the vehicle of sound and speech. A smaller portion of oxygen, and a larger portion of carbonic acid, is contained in the air which is exhaled, than in that which is inhaled. There are also, aqueous particles in the breath, which are precipitated, by the coldness of the external air, in the form of visible vapour; likewise other substances which owe their origin to secretions in the mouth, nose, windpipe, and lungs. These cause the changes in the breath, which may be known by the smell, like the other qualities of the air. In youth the breath is insipid, and contains acid: it loses these qualities after the age of puberty, and becomes more agreeable. With advancing age, it becomes again unpleasant. A bad breath is often caused by local affections in the nose, the mouth, or the windpipe: viz. by ulcers in the nose, cancerous *polypi*, by discharges from the mouth, by sores on the lungs, or peculiar secretions in them. It is also caused by carious teeth, by impurities in the mouth, and by many kinds of food (viz. horse-radish, onions, and also by flesh, if used to the exclusion of other food), and by fevers. In the last case, it often varies with the character of the disease. The remedy for this complaint must depend on the causes which produce it. Substances of an aromatic kind, which have a strong, rich smell, should be chewed to diminish its offensiveness. Parsley has been found of peculiar use; but it is often impossible to remove this unpleasant disorder. According to the Prussian code, a bad breath furnishes ground for a divorce.

Breathing. The mechanism of the respiratory organs will be discussed under the head of Respiration; but there is a species of breathing of a very marvellous character, of which some account has been given by Dr. Brewster, in his *Natural Magic*, which should be noticed here: One of the most ancient feats of magic was the art of breathing flame, an art which even now excites the astonishment of the vulgar. During the insurrection of the slaves in Sicily, in the second century before Christ, a Syrian named Eanus acquired by his knowledge the rank of their leader. In order to establish his influence over their minds, he pretended to possess miraculous power.

When he wished to inspire his followers with courage, he breathed flames or sparks among them from his mouth, at the same time that he was rousing them by his eloquence. St. Jerome informs us, that the Rabbi Barchochebas, who headed the Jews in their last revolt against Hadrian, made them believe that he was the Messiah, by vomiting flames from his mouth; and at a later period, the Emperor Constantius was thrown into a state of alarm when Valentian informed him, that he had seen one of the body-guards breathing out fire and flames. We are not acquainted with the exact methods by which these effects were produced; but Elorus informs us, that Eunus filled a perforated nut-shell with sulphur and fire, and having concealed it in his mouth, he breathed gently through it while he was speaking. This art is performed more simply by the modern juggler. Having rolled together some flax or hemp, so as to form a ball the size of a walnut, he sets it on fire, and allows it to burn till it is nearly consumed: he then rolls round it while burning some additional flax, and by these means the fire may be retained in it for a considerable time. At the commencement of his exhibition he introduces the ball into his mouth, and while he breathes through it the fire is revived, and a number of burning sparks are projected from his mouth. These sparks are too feeble to do any harm, provided he inhales the air through his nostrils.

Breeching; a rope used to secure the cannon of a ship of war, and prevent them from recoiling too much in the time of battle. It is of sufficient length to allow the muzzle of the cannon to come within the ship's side to be charged.

Breezes, *Sea*, *Land*, and *Mountain*. See Winds and Atmosphere.

Breve; a note of the third degree of length, and formerly of a square figure, as ⊏⊐; but now made of an oval shape, with a line perpendicular to the stave on each of its sides: |○|. The breve, in its simple state, that is, without a dot after it, is equal in duration to one quarter of a large, or to two semibreves, and is then called *imperfect;* but, when dotted, it is equal to three-eighths of a large, or to three semibreves, which being the greatest length it can assume, it is then called *perfect.*

Brevis Cubiti, in *Anatomy;* one of the extensor muscles of the cubitus, arising from the external spine of the humerus.

Brewing, is the art of preparing a vinous liquor from farinaceous seeds, particularly malt. The juices of fruits contain sugar, which is essential to the vinous fermentation. But this does not exist, in any important quantity, in seeds. Instead of it, however, we have starch, and this may combine with water, so as to form sugar. This combination is performed very perfectly by a vital process; that is to say, it takes place only in a living seed, and not in one which is frozen, burned, or otherwise killed. It is known by the name of *germination* or *growing,* and is of familiar occurrence, being what takes place in every seed that is successfully planted. The seeds of wheat, rye, barley, &c., consist principally of starch. If a grain of these is examined, we find near one end of it a small body, which is the rudiment of the future plant, and the microscope shows us that this consists of two parts—the *plumula,* which is destined to ascend through the earth to form the stalk, and the *radicle,* which is to be spread abroad below, and form the root. Whenever a grain of barley, oats, or certain other of the gramineous seeds, is exposed to water, it begins to swell and absorb the moisture; and, at the same time, if the temperature of the air is not too cold, the radicle thrusts itself out at the lower end; the plumula, on the other hand, pushes itself along beneath the husk of the grain to the other end, before it thrusts itself out. There are several curious considerations in regard to this process. The one which concerns us at present is this, that, as the plumula is passing along through the husk, the part of the seed along which it passes becomes changed into the substance known in chemistry by the name of *starch sugar;* that is, when the plumula has passed along one-third of the length of the grain, that third is starch sugar, while the remaining two-thirds are still starch; and so with the rest. The starch sugar seems to be some combination of starch and water. The final cause of the change is undoubtedly the support of the growing plant, sugar being evidently necessary to the growth of plants, as it is always found in their sap, and sometimes, as in the sugar maple, in great quantities. The moment, however, the plumula begins to protrude beyond the end of the grain, the sugar diminishes, as it is consumed by the young stalk; and the substance of the seed is also consumed, though by no means to the same extent, by the growth of the root. To produce this change in seeds, and thereby to fit them for yielding a sweet fluid, when mixed with water, is the business of the maltster; and it is an operation of great delicacy, upon the successful performance of which the success of a manufactory of ale or beer in a great measure depends. The first step in brewing is called *mashing.* It consists in stirring up the malt with a quantity of hot water, which dissolves the starch sugar of the malt, and forms a sweet liquor called *wort,* similar to the must, or sweet juice of the grape, from which wine is made. The manufacture differs, however, in some essential particulars, at this stage of the process, from that of wine; for, if the wort were allowed, as the must is, to ferment without obstruction, it contains so much of the mucilage and starch of the grain, that it would run into the acetous, and from thence into the putrefactive fermentation, and would be *foxed,* as it is technically termed; that is, it would become ill-smelling vinegar instead of beer. To prevent this, it is first boiled. This process renders it stronger, by evaporating a portion of the water; and, farther, it coagulates or curdles the mucilage, which subsides afterwards, and is not again dissolved, thus separating an injurious ingredient. While boiling, a portion of hops is added. One object of this is to give an aromatic, bitter taste to the liquor, which habit has rendered agreeable. The principal object of adding the hops, however, is to check the tendency to the acetous fermentation, which is always far greater, in liquor so compound in its character as beer, than in the simpler liquors, as wine and cider. It is also a common opinion, that hops adds to the intoxicating qualities of the article; and this opinion is probably well founded. One important improvement has been acted on with great success, and which offers a complete safeguard against an accident that often spoils a whole mash.

It is thus described:—the patentee had observed that, in the common way of boiling the wort, the extract is often, if not always, more or less burned; to prevent which, he never suffers fire or flame to

come in contact with the vessel in which the wort is boiled, but performs that process by means of steam, applied on the outside of that vessel. For this purpose he incloses the brewing-vessel in another vessel called the case or jacket, made either of metal or wood, with a sufficient space left between them for the admission of steam from a boiler, by means of tubes, or other convenient communication. In arranging this simple apparatus, attention should be paid to the following particulars: the brewing-vessel must be so well secured in its case, that there may be no way for the steam to escape, but through a valve or cock. The brewing-vessel should rise somewhat higher than the case, as it is not advisable to apply the steam to that vessel higher than the worts within it rise to, as some portions of the hop are apt to adhere to the sides of the vessel, and these, if exposed to a greater heat than the worts, might injure the flavour of the beer. The boiler which supplies the steam should be furnished with a steam-valve, and placed somewhat lower than the brewing-vessel; so that the water produced by the condensation of the steam in the case may be returned to the boiler by a tube. The tube which connects the boiler and the case should be furnished with cocks, that the steam may be excluded or admitted at pleasure. By employing a close brewing-vessel with a safety-valve, the temperature of the wort may be raised above the common boiling temperature of 212°, and a larger portion of extract may thus be obtained from the hop. The flavour of the beer thus brewed is represented as superior to that boiled in the common way, and as being, when properly fermented, more vinous, spirituous, and palatable. After the worts are sufficiently boiled, they are poured out into large shallow cisterns or coolers, till they become cool, and deposit much of the curdled mucilage. They are then allowed to run into a deep tub or vat to ferment. If left to themselves, however, the process would take place very imperfectly, and it is therefore assisted by addition of yeast. The true nature of this substance, notwithstanding much attention and some laborious analyses, is not yet understood. It excites fermentation, however, which continues for a period of time longer or shorter, according to the fancy of the brewer, and is then checked by drawing off the liquor into barrels or hogsheads. In these the fermentation still goes on, but it is now called by brewers *cleansing*. With a view to take advantage of this process, the casks are placed with their bung-holes open, and inclined a little to one side. The scum, as it rises, works out at the bung, and runs over the side, and thus the beer is cleansed from a quantity of mucilage, starch, and other unfermented matters. What does not run out at the bung subsides to the bottom, and constitutes the *lees*. After this cleansing is completed, the clear beer is racked off into barrels, and preserved for use. The scum and lees are collected, and the former constitutes the yeast for the next brewing.—Such is the general history of brewing, whether the product is to be beer, ale, porter, or wash, except that in the latter the cleansing is not necessary.—Even this racking, however, does not remove all the unfermented matter. Some starch and gluten still remain; of course, the liquor soon begins to ferment again in the barrels; but, as these are closely stopped, the carbonic acid gas, or fixed air, cannot escape, but becomes mingled with the beer. Every successive fermentation causes some lees, from which the beer may be racked off, and, by repeated racking, the fermentative matter may be completely removed, and such beers become clear, transparent, and somewhat like the German wines, as, for instance, that commonly called *hock*. But, the disposition to ferment being thus entirely destroyed, they are, like these wines, perfectly still, and acquire no disposition to froth by being bottled. Hence old sound beers may remain in bottles for years without *coming up*, as it is technically called. The object of the brewer is to produce an agreeable beverage, distinguished not so much for absolute strength, or quantity of alcohol, as for colour, flavour, transparency, liveliness, and power of keeping well. Some of these qualities are not compatible with the developement of the greatest quantity of alcohol or ardent spirit, which is the main object of the whiskey-distiller. To effect this purpose, he makes a kind of beer, which is called *wash*. This differs from brewers' beer in some important particulars. In the first place, the grain is not all malted: in England, only a part of it is so; in the United States, generally, none at all. In the next place, it is ground a great deal finer than in brewing. If the brewer were to grind his grist as fine as the distiller, he would run great risk of *setting his mash*, as the phrase is; that is, he would make paste of his grain, and entangle the solution of sugar so effectually, that he could not get it out again. The distiller does not run the same risk, because he does not use such hot water as the brewer, and he can mash and stir his wash a great deal longer without injury, and even with benefit to his liquor. Again, he does not need to boil or add hops to his worts, for he does not care about precipitating the mucilage, or making his beer keep. In the next place, he adds a great deal of yeast, and ferments violently and rapidly, so as to decompose the sugar as quickly as possible, and is quite indifferent whether the worts even become somewhat sourish in the process, as, when sufficiently fermented, the alcohol is removed at once by distillation. If raw grain be ground, mixed with water at a certain heat, and allowed to stand, the change of the starch into starch sugar, or the combination of starch and water, takes place in the same way as in malting. It takes some time, however, and hence the distillers' mashes stand longer than the brewers'. It would seem, therefore, from this, that the malting of grain is not necessary for the making of beer; and, accordingly, this method of proceeding has been recommended by an eminent chemist, one who has paid much attention to this subject, and there can be no doubt that a certain description of small beer may be so made. But the process is not applicable to the finer and more valuable kinds of malt liquors, for reasons which it would require too many details to explain perfectly. Besides the kinds of beer and wash already mentioned, there are others in very common use in America. These are made by mixing honey, molasses or sugar with water, and fermenting with yeast, or some other leaven. Beers made in this way are commonly mingled with some vegetable substance, as ginger, spruce, sarsaparilla, &c., to give them a particular flavour, and are familiar to all by the names of *ginger beer*, *spruce beer*, *sarsaparilla*, &c. &c. The wash of this kind is made from molasses and water, fermented in large vats under ground, by means, not of yeast, but the re-

mains or returns of former fermentations. See ALE, BEER, and PORTER.

BRICK is a sort of artificial stone made principally of argillaceous earth, formed into moulds, dried in the sun, and baked by burning. The use of unburnt bricks is of great antiquity. They are found in the Roman and Grecian monuments, and even in the ruins of Egypt and Babylon. They were dried in the sun instead of being burnt, and mixed with chopped straw, to give them tenacity. On account of the extreme heat and dryness of the climate, they acquired great hardness, and have lasted for several thousand years; but they are unsuitable for more northern latitudes. The most common bricks, among the Romans were 17 inches long, and 11 broad; and, in later periods, they were burned.

BRICK-MAKING has, of late years, furnished a very considerable branch of trade around the metropolis, not only very productive to the land-owners, but it has produced an extensive help to the revenue of the country; yet, much of the brick now in use will hardly wear out a twenty-one years' lease. That there must be something radically wrong in the present system of manufacturing the brick earth, is very evident, as we have the same means of procuring brick earth equally fit for the purpose as formerly. With this impression, we think it may be beneficial to furnish our readers with the theory and practice of brick-making, as drawn up some time since by Mr. James Malcom.

He observes, that the manufacture of them is of the utmost importance to the community, inasmuch as the value and comfort of our dwellings must depend in a great measure on the quality of the materials with which they are constructed; and bricks form no inconsiderable part of them. I say, it is material to us, because, if the bricks with which our houses are now almost uniformly built, are in quality defective, and if the timber be of a similar description, we ought not to place much dependance on the solidity of the edifice.

The soil on the Surrey side of London is only calculated for certain sorts of bricks, and these, it must be confessed, are inferior to those made in Middlesex. We have neither depth nor that pure argillaceous substance, which is so essential to form the perfect brick; we have either too much silex, or, to speak the common language, too much flinty sand; and the stones are too abundant, large, and too near the surface, which causes the bricks to vitrify, and thereby their colour and quality is injured; or we have a portion of calcareous matter, which causes the bricks, after being taken from the clamps, insensibly to moulder away by exposure to the air or moisture; and were it as argillaceous as in Camberwell and Dulwich parishes, it is to that extreme, as to be impossible to be moulded without the assistance of some adventitious combinations. What those combinations were, which form the several varieties of bricks manufactured in the county, together with some cursory remarks, will form the subject of this essay.

At Kennington, at Walworth, at Camberwell, and in Battersea parishes, we have manufactories of bricks to a much greater extent probably, than all the rest of the county united. In analyzing the earth which has been generally used, I followed the plan of the learned Bishop of Landaff. Eight ounces of earth taken out of the pit as they were digging (Mr. Fentiman's) and moulding it into an oblong square, I placed on the hob of a Bath stove in my study, where a constant fire was kept for seven days. I then weighed it, and found it had lost one ounce and three quarters. I did the same by that at Walworth, and during the same time it lost nearly two ounces; that at Camberwell lost in the same time three ounces four pennyweights; that at Battersea, two ounces six pennyweights. In the solution of these earths, after having exposed them to the muriatic and the acetous acid, it was evident that, besides a large portion of pure argil which the earth at Camberwell contained, there were not less than eighteeen parts in one hundred of iron, a small portion of silex, and about six parts in one hundred of calcareous earth: and it will be seen, that the quantity of water which the clay and the calcareous earth held, was considerable; from this I infer, that, although the colour of the bricks, and the difficulty and consequent expense in moulding the latter was greatly against the manufacture, yet, as to the materials, they were far superior to the others in an essential property, I mean durability. Those at Kennington and Walworth were nearly similar in their products, the latter possessing the most argil; and those at Battersea still more; the earth therefore imbibing more moisture, consequently loses more in burning.

The moulds used in making every sort of brick for building purposes are ten inches in length, and five in breadth; and the bricks when burned usually measure nine inches in length, and four and one-half in breadth, so that the clamp shrinks about one inch in ten. But the degree of contraction (as we have before seen) which clay undergoes in being burned, does not absolutely depend upon the purity of the clay; for as some clay imbibes more moisture than others, if that which imbibes the most is not exposed a much longer time to the frost to divide and separate its particles, and to the heat of the sun to exhale its moisture, than that which imbibes less and is a shorter time exposed, it follows, that while the one will be reduced one inch, the other may lose two or more. Again, the heat of the kiln or clamp, and the situation of bricks as to heat will vary the diminution of the subject to be burnt. It is of consequence, therefore, in the making of sound hard bricks, that the clay should be dug two or three years before it is used, in order that it may be pulverised; and the oftener it is turned and incorporated, the better will be the bricks. The earth should have sufficient time to mellow, ferment or digest, which will render it more apt and fit to temper; and this operation of treading and tempering ought to be performed more than double the usual time, because the goodness of the bricks wholly depend upon the well performance of its first preparation, since the earth in itself, before it is wrought, is generally brittle, full of extraneous matter, which requires to be removed, and as it were without unity and stability; but by adding small quantities of water by degrees to it, and working and incorporating it together, the several parts of it are opened, and by being thus exposed to the atmosphere a tough and gluey substance is formed, which, without such tempering, treading, and beating, could not have been produced. I can only compare this preparation of the soil to that of making bread. When there is a due quantity of water put to the flour, and well wrought up together, such bread comes not only

smooth and firm, without having eyes or being subject to crumbling, but it eats sweeter and mellower, and becomes easier of digestion, affording far better nourishment than such as is over-watered, heavy, and not sufficiently tempered; provided the other operations, which belong to the making of good bread, such as baking, &c. be properly performed.

Bricks thus tempered become solid, smooth, hard, and durable; and one brick thus made takes up nearly as much earth as a brick and a half made in the common way; but these are light, full of cracks, and spongy, owing to the want of due working and management; and the mixing of ashes, which is now the uniform practice about London, and light sandy earth which is usually practised in the country, to make them work easy and with greater dispatch, serves also to save coals or wood in the burning of them. See *Malcolm's Survey*.

The excellency of bricks consists chiefly in the first and last operation; for bricks made of good earth and well tempered, become solid and ponderous, and therefore will take up a longer time in drying and burning than our common bricks seem to require. It is also to be observed, that the well drying of bricks before they are burned, prevents cracking and crumbling in their burning; for when the bricks are too wet, the parts are prevented from adhering together. The best way of ordering the fire is to make it gentle at first, and increase it by degrees as the bricks grow harder. If those several operations were properly and duly attended to, we should not see such immense waste, and so great a profusion of unburnt and half-burnt bricks, called place bricks, as we constantly find on the outsides of our modern clamps. For want of due precaution the fire never reaches them in an equable degree, and therefore they ought to be totally disregarded and laid aside; but modern ingenuity, and the tricks of the builders, have found out a mode of using them, less objectionable to be sure than if they were consigned to the outside walls, though properly they are not fit to be used any where. It is necessary that the public should be informed, that these place bricks are now made use of in the inside walls of houses of every denomination, from the hut to the palace; and that they are soft, subject to very quick decay, and wherever wet can at all get to them, they moulder away with great rapidity; nor is this the only objection to them; they are subject to be acted upon by every change of the weather, so that the walls become damp, and the plastering discoloured, causing the bond timbers and plates to rot; and for want of equal solidity with the external bricks, the walls crack, and the timbers swag, because the bearing on them cannot be then any where equally poised.

The dampness which so often affects the inside walls, is attempted to be palliated or removed by the introduction of what is called battening, whereby an opening or cavity is left between the brick-work or plastering; but whoever has attentively observed the result of this invention, which in very many instances has fallen to my lot to notice, will see that the damp arising from these bricks engenders mould, and is visible on the frame of the wood used in the battening; this mould is, no doubt, the secondary cause of the dry-rot, since the origin must be in the bricks themselves.

That this is the case, may be deduced from this fact, that wherever a quantity of those bricks is heaped up together for any length of time, they will upon separation be found to have their bases covered with a fine white net-work, especially those which are nearest the bottom. Hard burnt, sound bricks never have this net-work grow upon them, let them lay as long as they may in any situation. This net-work then is the plantulæ of mould. The origin and increase of mould is nearly in proportion to the heat of the atmosphere; its appearance and vegetation are never more sudden than during the summer, and the reason seems to be, that the heat of the weather necessarily draws out the redundant moisture from the bricks for want of a due circulation of air. This moisture attaches itself to the outside of the bricks, and there remains, the heat not being sufficient to dry it up, but enough perhaps to produce a degree of warmth; it enters into a slow but certain process of fermentation; and, passing through a state of acidity to putrefaction, is of itself sufficient to engender mould. Sometimes it is very long before mould is produced on particular substances, either from the absence of the seed, or the substance not being well adapted for its vegetation; while in others, the seed has been known to vegetate in three hours. The mould, from being first white, turns yellowish, and at last blackens. As it approaches a state of maturity, a kind of black dust falls from it, which is the seed of the plantulæ; a quantity of this dust constitutes the powder, which blackens the hand when touched. As this dust and seed is so fine and infinite, it spreads with a rapidity equal to the state and condition of the substances which may be fit to receive it, and hence may attack a whole building, and becomes the means of endangering and eventually destroying the most superb edifice.

Another fact will confirm this reasoning. In pulling down the most ancient houses not an atom of dry-rot has been visible, but merely a decay in the timbers, occasioned by age, because the bricks inside and out were alike hard and sound; but where modern ones have been erected on the old sites, a very few years have been sufficient to prove that symptoms of dry-rot have manifested themselves in the basement, from the great degree of humidity which prevails there.

If such bricks, therefore, are not timely removed, all the art of man cannot prevent the effects of the dry-rot. It is the same with certain sorts of stone, which are always damp, be the weather what it may, and there the dry-rot makes the greatest havoc.

Bridge. It is needless to investigate ancient authors for a description of the primitive bridge, as its origin and elements are to be found in uncultivated nations of modern times. Stepping-stones, in shallow rivers, covered with planks from stone to stone, exhibit the incipient principles of piers and arches, which science has brought to their present perfection. In deeper rivers, an accumulation of stones forms a loftier pier; and, where the openings were sufficiently narrow, and the slabs of stone sufficiently long, or the art and strength of the untaught architect sufficient to the task, a roadway was formed from pier to pier, like the Vitruvian architrave of the primitive Tuscan temple. With the Greeks, who were a more maratime people, and more accustomed to navigation than the Romans, there is no doubt that ships and boats preceded, if they did not supersede, the use of bridges. In their brightest days, when their fine style of architecture was complete, when their porti-

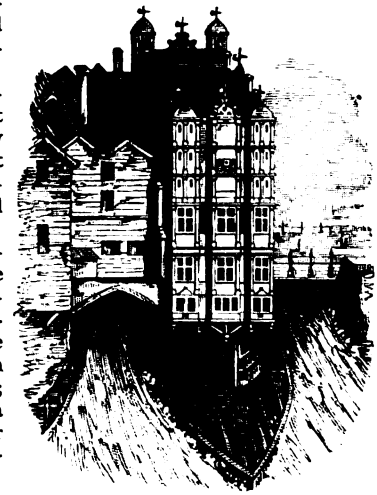
coes were crowded with paintings, and their streets with statues, the people of Athens waded or ferried over the Cephisus for want of a bridge. The Greeks do not seem to have valued the construction of the arch sufficiently to excel in bridge-building. No people of the ancient world carried the power of rearing the stupendous arch and the magnificent dome to such an extent as the Romans. After the construction of their great sewers, the aqueducts, and the cupola over the Pantheon of M. Agrippa, a bridge over the Tiber was of easy execution; and the invention of the architecture of stone bridges, as practised in its best and most effectual manner, must be conceded to this great and indefatigable people. The most celebrated bridges of ancient Rome were not distinguished by the extraordinary size of their arches, nor the peculiar lightness of their piers, but, like the rest of the magnificent works of this city, as far as construction is concerned, they are worthy of study from their excellence and durability. The span or chord of their arches seldom exceeded 70 or 80 feet, and the versed sine or height was nearly half of the chord, so that they were mostly semi-circular, or constituted a segment nearly of that form.

Among the most celebrated brigdes in modern times, or those built subsequently to the destruction of the Roman empire, are those of the Moors in Spain, who imitated and rivalled the best constructions of the Romans. The bridge of Cordova, over the Guadalquivir, is an eminent example of their success. The bridge over the Rhone, at Avignon, is one of the most ancient bridges of modern Europe. It was built by a religious society called the *Brethren of the Bridge*, which was established upon the decline of the second, and the commencement of the third race of French kings, when a state of anarchy existed, and there was little security for travellers, particularly in passing rivers, on which they were subject to the rapacity of banditti. The object of this society was to put a stop to these outrages, by forming fraternities for the purpose of building bridges and establishing ferries and caravansaries on their banks. The bridge of Avignon was commenced in 1176, and completed in 1178. It was composed of 18 arches. The length of the chord of the largest was 110 feet 9 inches, and its height 45 feet 10 inches. France can boast of many fine bridges, built during the last two centuries.

In Great Britain, the art of building bridges appears to have been diligently studied from early times. The most ancient bridge in England is the Gothic triangular bridge at Croyland in Lincolnshire, said to have been built in 860. The ascent is so steep that none but foot-passengers can go over it. The old bridge which connected London and Southwark was a very singular edifice, and a view of its peculiar architecture will serve to give our readers a notion of the state of knowledge in this important branch of hydraulic engineering at an early period.

This bridge appears to have been completed in the twelfth century, and a slight view of its narrow arches and massive abutments will serve to show how little science was displayed in its erection.

The bridge was crowded with buildings, and we select one of the most remarkable, called Nonesuch-House. Our view is taken from the *Chronicles of London Bridge*, one of the most elegant specimens of antiquarian learning in our language. Like most of the other buildings, this celebrated edifice also overhung the east and west sides of the bridge; and there presented to the Thames two fronts, of scarcely less magnificence than it exhibited to Southwark and the city; the columns, windows, and carving, being similarly splendid; and thus equally curious and interesting was the Nonesuch-House on London Bridge, seen from the water. Its southern front only, however, stood perfectly unconnected with other erections, that being entirely free for about fifty feet before it, and presenting the appearance of a large building projecting beyond the bridge on either side; having a square tower at each extremity, crowned by



short domes, or Kremlin spires, whilst an antiquely-carved gable arose in each centre. The whole of the front, too, was ornamented with a profusion of transom casement windows, with carved wooden galleries before them; and richly sculptured wooden panels and gilded columns were to be found in every part of it. In the centre was an arch of the width of the drawbridge, leading over the bridge; and above it, on the south side, were carved the arms of St. George, of the city of London, and those of Elizabeth, France and England quarterly, supported by the lion and dragon; from which circumstance only can we estimate the time when the Nonesuch-House was erected.

The new bridge is extremely striking from its contrast with the Gothic edifice, whose place it supplied. It consists but of five elliptical arches, which embrace the whole span of the river, with the exception of a double pier on either side, and between each arch a single pier of corresponding design: the whole is more remarkable for its simplicity than its magnificence. The following is a statement of the dimensions of the new bridge:—

Centre arch—span, 150 feet; rise, 32 feet; piers, 24 feet.

Arches next the centre arch—span, 140 feet; rise, 30 feet; piers, 22 feet.

Abutment arches—span, 130 feet; rise, 25 feet; abutment, 74 feet.

Total width, from waterside to waterside, 690 feet.

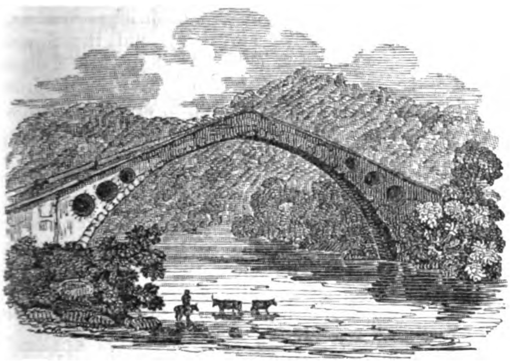
Length of the bridge, including the abutments, 930 feet; without the abutments, 782 feet.

Width of the bridge, from outside to outside of the parapets, 55 feet; carriage-way, 33 feet 4 inches.

Blackfriars bridge is handsome in design, and its elliptical arches are well suited to its situation, but its material is bad and perishable. This bridge was designed and erected by Robert Milne, an able Scotch architect. It was commenced in 1760, and com-

pleted in 1771. It is 995 feet long, and 43 feet 6 inches broad between the parapets. The centre arch is 100 feet in span, and 41 feet 6 inches in height. *Waterloo bridge* is one of the greatest architectural works of our times. It is the only bridge over the Thames which has a flat surface in its whole course. Its length is 1250 feet. It consists of 9 elliptical arches, each of 120 feet span, and 32 feet in height, Westminster bridge was commenced in 1740, and completed in 1750. It is 1220 feet long, and 44 feet between the parapets, has 13 large and 2 small arches, all semi-circular. The middle arch is 76 feet in span.

One of the most curious provincial bridges in Great Britain is that at Taff, in Glamorganshire. It is of one arch, and its space is rather more than 140 feet.



The architect of this bridge was a poor, uneducated man, and the persevering courage with which he pursued his object till the completion of the edifice, is worthy of record. His first attempts failed in consequence of the enormous pressure of the haunches or sides of the bridge, which forced up the key-stone, and to obviate this, he pierced the stone-work with cylindrical apertures, which remedied the defect. Prior to the erection of this bridge, that of the Rialto had the largest span of any in existence.

Metal bridges are the invention of British artists. The true elements of their construction are as yet but imperfectly understood. The first bridge of cast-iron ever erected is that over the Severn, about two miles below Colebrook-dale, in Shropshire. It is an arch composed of five ribs, forming the segment of a circle. Its chord is 100 feet long, and its height 45 feet. It was erected in 1777. The second cast-iron bridge was designed by Thomos Paine, the celebrated political writer, and was intended to have been taken to America; but, the speculator failing in his payments, the materials were afterwards used in constructing the beautiful bridge over the river Wear, at Bishop's Wearmouth, in the county of Durham. The chord of the arch is 240 feet long; the height, 30 feet. The Southwark bridge over the Thames is, at present, the finest iron bridge in the world. It consists of three arches. The chord of the middle arch is 240 feet long, and its height 24 feet. There are several other fine bridges of this kind in England. Mr. Telford proposed an iron arch of much larger dimensions than any now existing, to take the place of London bridge. The length of the chord was to be 600 feet, and its height 65. The plan was not however considered practicable.

Timber is the most ready, and perhaps the most ancient material used for the construction of bridges. The earliest timber bridge on record is that thrown by Julius Cæsar over the Rhine, and described in his *Commentaries*. Germany is the school for *wooden bridges*, as England is for those of iron. The most celebrated wooden bridge was that over the Rhine at Schaffhausen. This was 364 feet in length, and 18 feet broad. The plan of the architect was, that the bridge should consist of a single arch. The magistrates of the place, however, required that he should make it of two, and use the middle pier of a stone bridge, which had previously stood there. He did so, but contrived to leave it doubtful whether the bridge was at all supported by the middle pier. It was destroyed by the French, in April, 1799. The same architect and his brother have also erected several other fine arched wooden bridges. Several others have been erected in Germany, by Wiebeking, perhaps the most ingenious carpenter of our times.—In the United States, the Trenton bridge over the Delaware, erected by Burr in 1804, is the segment of a circle 345 feet in diameter. Its chord measures 200 feet; its height, or versed sine, is 32 feet, and the height of the timber framing of the arch, at its vertex, is no more than 2 feet 8 inches. The timber bridge over the Schuylkill, at Philadelphia, is of the extraordinary span of 340 feet. The versed sine is only 20 feet, and the height of the wooden framing at the vertex, 7 feet. Its architect was Wernwag, who built it in 1813. The bridge built by Palmer, over the Piscataqua, near Portsmouth, New Hampshire, in 1794, is the segment of a circle 600 feet in diameter. Its chord line measures 250 feet, its versed sine 27 feet 4 inches, and the height of the timber frame-work of the arch 18 feet 3 inches. It is put together with wooden keys. The same ingenious mechanic erected two other wooden bridges, one over the Merrimack, at Deer Island, near Newburyport, of 160 feet diameter, finished in 1792, and the other over the Schuylkill at Philadelphia, of 194 feet chord, and 12 feet versed sine, being the segment of a circle 796 feet in diameter. This was finished in 1803.

There were suspension bridges both in America and India long prior to their general use in this country.

The little river of Chambow, which flows from the lake of Coley, separates the beautiful village of Guanando from that of Penipe. It runs through a ravine, the bottom of which is elevated 2400 metres above the level of the sea; and which has long been famous for the production of cochineal, in the preparation of which, the inhabitants have been employed from the remotest antiquity. The river (says M. de Humboldt) is crossed by one of those bridges of cords which the Spaniards call *puente de maroma*, and the Peruvian Indians, *cimppacha*, from *cimppa*, ropes, and *chaca*, a bridge. The ropes, which are three or four inches in diameter, are made from the fibrous roots of the American agavey. They are attached to a wooden scaffolding composed of the trunks of several trees, erected on the shore, on each side of the river, and upon them are laid small round pieces of bamboo, placed transversely.

As the weight of the bridge causes the trees to bend towards the middle of the river, and as it would be imprudent to strain them with too much force, it becomes necessary (although the shores of the river are not very high) to construct steps or ladders at the two extremities of the bridge. This bridge is

120 feet long, and 7 or 8 feet wide; but there are others of this construction, whose dimensions are considerably larger.

These structures, which the South Americans made use of long prior to the arrival of the Europeans, greatly resemble the bridges of chains that are met with in China, and in the interior of Africa. Mr. Turner, in his interesting *Voyage to Thibet*, has given the plan of the bridge of Ichinchieu, near the fort of Chuka (lat. 27° 14′), which is 140 feet long, and which may be passed over on horseback. This bridge is supported by five chains covered with pieces of bamboo.

All travellers have spoken of the great danger which attends the passage of these rope bridges, which are suspended like ribands across a deep ravine or impetuous torrent. The danger, however, is not very great (says Baron Humboldt), when a single person passes over by himself, especially if he run as quickly as possible, throwing the body forward. But the oscillations of the ropes become very violent when the traveller is conducted by an Indian, who walks much quicker than he, or if affrighted by the appearance of the water, seen between the interstices of the bamboos, he is imprudent enough to stop in the middle, and lay hold of the ropes which serve for balustrades.

A rope bridge seldom remains in good condition longer than twenty or twenty-five years; and even then it becomes necessary to replace some of the ropes every eight or ten years. But the internal regulations of this country are so lax, that it is not uncommon to see bridges, in which the flooring of bamboo is broken into large piece; and it is then necessary to walk with much circumspection over those ancient structures, in order to avoid the holes, which are sometimes large enough to precipitate the unwary traveller into the water, or the ravine beneath. A few years before my arrival at Penipe (says M. Humboldt), in consequence of long continued rains, which were succeeded by a very dry wind, the suspension bridge of the Rio Chambo fell to pieces. Four Indians were drowned in the river, which is very deep, and its current extraordinarily rapid.

The ancient Peruvians constructed bridges of wood, which rested upon piles of stone; but they most commonly contented themselves with bridges of ropes, which are extremely useful in a mountainous country, where the depth of the ravines, on the impetuosity of the torrents, prevent the constructing of piles. The violence of their swinging may be diminished by lateral ropes attached to the middle of the bridge, and stretching diagonally towards the shore.

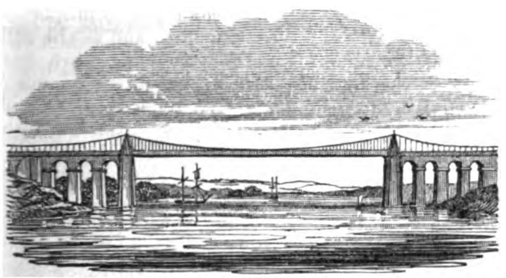
It is by means of a bridge of ropes of extraordinary length, which may be traversed by loaded mules, that the South Americans have succeeded (within these few years) in establishing a permanent communication between the towns of Quito and Lima, after having uselessly expended a million of francs in constructing near Santa, a stone bridge over a torrent which descends from the Cordilleras of the Andes.

The simplicity of construction observable in these fragile works of art, and the small expenditure of time and labour which they require, were advantages particularly suited to the narrow genius and slender mechanical knowledge of this simple people. No doubt, if these bridges were exposed for a short time to the vicissitudes of an European, or at least of an English climate, catastrophes similar to that recorded by Baron Humboldt, would occur so frequently, as to oblige the South Americans to construct their bridges of more durable and solid materials. And as we find that the progress of mankind, in the path of science, has been rapid in proportion to the necessities of their situation, and as the calls upon their energies and understanding have been more or less imperative, so, no doubt, the science of bridge-building with the South Americans, will ultimately approach to the perfection of the European art.

The suspension principle for bridges has likewise been adopted in India. In the Calcutta government gazette, is a description of a suspension-bridge, which has lately been erected at Aligpore, of materials quite novel in the history of bridge-building, and in a manner alike surprising and ingenious. This bridge, which was constructed by Mr. Cohen Shakespeare, consists entirely of cane with iron fastenings, and is 130 feet in length, and 5 in width. The canes, which are from 100 to 225 feet in length, and from 1 to nearly 2 inches in diameter, were procured from the north-eastern frontier (where they may be had for the trouble of collecting them), and sent to Calcutta coiled up like ropes. Eighteen canes form the bearings; these are lashed together at each end of the bridge, and upon them are laid cross slips of bamboo, as in the construction of rope bridges. Not only the roadway, but also all the contrivances for steadying the bridge, and preventing oscillation, are of iron, and are well arranged. These materials, of course, prevent the danger and difficulty which would attend the passage; the bridges described by M. Humboldt in these parts were entirely of cane. The appearance of the arch is described as singularly light, even more so than rope; and it is in reality lighter as a whole, because the cross bamboo slips, forming the roadway, are lashed at once to the canes; and thus it becomes firmer than in the rope bridge, in which the treadway is distinct, and lies over the strands. The strength and durability of the cane are by some considered equal to that of rope; this is a question that time will solve. Should the cane, however, last only a season or two of the rains, and it is strongest when kept moist, the advantages gained to the country will be incalculable, as it abounds with that cheap and useful commodity.

Suspension bridges were in use in Europe in the time of Scamozzi, as may be seen in his *Del Idea Archi*, 1615; yet the principles requisite to determine the structure of this kind of bridges had not been made public before the time of Bernouilli. The use of these bridges is of great antiquity in mountainous countries. The most remarkable bridge of suspension in existence is that lately constructed by Mr. Telford over the Menai strait, between the isle of Anglesea and Caernarvonshire in Wales. It was finished in 1825. The roadway is 100 feet above the surface of the water at high tide. The opening between the points of suspension is 560 feet. The platform is about 30 feet in breadth. The whole is suspended from 4 lines of strong iron cables by perpendicular iron rods, 5 feet apart. The cables pass over rollers on the tops of pillars, and are fixed to iron frames under ground, which are kept down by masonry. The weight of the whole bridge, between the points of suspension, is 489 tons. Some notion

of the vast space and gigantic proportions of this bridge may be collected from the fact exhibited in the accompanying engraving, of a large two-masted vessel being able to sail at once beneath its aerial roadway.



There is but one circumstance which appears at all to affect the stability of its equilibrium, and that is the heavy and measured tread of a long line of military. The whole weight of a number of men, whose feet drop at the same instant of time, would affect any suspension bridge.

The following remarks on the *construction* of bridges are from Bigelow's *Technology:* "The construction of small bridges is a simple process, while that of large ones is, under certain circumstances, extremely difficult, owing to the fact, that the strength of materials does not increase in proportion to their weight, and that there are limits, beyond which no structure of the kind could be carried, and withstand its own gravity. Bridges differ in their construction, and in the materials of which they are composed. The principal varieties are the following:—

"*Wooden bridges.* These, when built over shallow and sluggish streams, are usually supported upon piles driven into the mud at short distances, or upon frames of timber. But, in deep and powerful currents, it is necessary to support them on strong stone piers and abutments, built at as great a distance as practicable from each other. The bridge between these piers consists of a stiff frame of carpentry, so constructed with reference to its material, that it may act as one piece, and may not bend or break with its own weight, and any additional load to which it may be exposed. When this frame is straight, the upper part is compressed by the weight of the whole, while the lower part is extended, like the tie-beam of a roof. But the strongest wooden bridges are made with curved ribs, which rise above the abutments in the manner of an arch, and are not subjected to a longitudinal strain by extension. These ribs are commonly connected and strengthened with diagonal braces, keys, bolts, and straps of iron.

"*Stone bridges.* These, for the most part, consist of regular arches, built upon stone piers constructed in the water, or upon abutments at the banks. Above the arches is made a level or sloping road. From the nature of the material, these are the most durable kind of bridges, and many are now standing which were built by the ancient Romans. The stone piers, on which bridges are supported, require to be of great solidity, especially when exposed to rapid currents, or floating ice. Piers are usually built with their greatest length in the direction of the stream, and with their extremities pointed or curved, so as to divide the water, and allow it to glide easily past them. In building piers, it is often necessary to exclude the water by means of a *coffer-dam.* This is a temporary enclosure, formed by a double wall of piles and planks, having their interval filled with clay. The interior space is made dry by pumping, and kept so till the structure is finished.

"*Cast-iron bridges.* These have been constructed, in England, out of blocks or frames of cast-iron, so shaped as to fit into each other, and, collectively, to form ribs and arches. These bridges possess great strength, but are liable to be disturbed by the expansion and contraction of the metal with heat and cold.

"*Suspension bridges.* In these the flooring or main body of the bridge is supported on strong iron chains or rods, hanging in the form of an inverted arch, from one point of support to another. The points of support are the tops of strong pillars or small towers, erected for the purpose. Over these pillars the chain passes, and is attached at each extremity of the bridge to rocks, or massive frames of iron, firmly secured under ground. The great advantage of suspension bridges consists in their stability of equilibrium, in consequence of which a smaller amount of materials is necessary for their construction than for that of any other bridge. If a suspension bridge be shaken, or thrown out of equilibrium, it returns by its weight to its proper place, whereas the reverse happens in bridges which are built above the level of their supporters.

"*Floating bridges.* Upon deep and sluggish water, stationary rafts of timber are sometimes employed, extending from one shore to another, and covered with planks, so as to form a passable bridge. In military operations, temporary bridges are often formed by planks laid upon boats, pontons, and other buoyant supporters." See Centering.

Brig, or Brigantine; a square-rigged vessel, with two masts. The term is applied to different kinds of vessels, by mariners of different countries. The term *brigantine* is also applied to a light, flat, open vessel, with 10 or 15 oars on a side, furnished also with sails, and able to carry upwards of 100 men. The rowers, being also soldiers, have their muskets lying ready under the benches. Brigantines are frequently made use of, especially in the Mediterranean, for the purpose of piracy, from which they derive their name. They are very fast sailers.

Brigade; in general, an indeterminate number oi regiments or squadrons. In the English army, a brigade of infantry is generally composed of 3 regiments: a brigade of horse, of from 8 to 12 squadrons; and one of artillery, of 5 guns and a howitzer. In the United States' army, the brigade is commonly composed of two, but sometimes more regiments. A number of brigades form a division, and several divisions an army-corps. A brigade-major is the chief of the brigade staff. A brigadier-general is the officer who commands a brigade. In the British service, this rank is now abolished. In the United States' service, he is next in rank to the major-general, who is the highest officer under the president, as commander-in-chief. *Brigadier-general* is also the title of the chief of the staff of an army-corps. In the French military language, *brigade*, in the cavalry, signifies a corporal's guard. Hence *brigadier* signifies a corporal.

Brigandine; a kind of defensive armour, consisting of thin jointed scales of plate, pliant and easy to the body.

Brimstone. Sulphur as first obtained, is mixed with foreign bodies, and, for the purpose of purification, is melted in a close vessel, by which the impurities are allowed to subside. It is then poured, in the liquid state into cylindrical moulds, in which it becomes hard, and is known in commerce by the name of *roll brimstone*. The inspired historian (Gen. xix. 24) relates that Sodom and Gomorrah were destroyed by fire from heaven. Showers of fire have been observed by Bergmann (occasioned by electricity), and showers of brimstone may be produced from the sulphuric acid which exists in the atmosphere.

Brittleness, in *Natural Philosophy*; that quality of bodies by which they are soon and easily broken by pressure or percussion.

Broach; any thing which will pierce through; a pin; that part of certain ornaments by which they are stuck on; the ornament itself. Among the Highlanders of Scotland, there are preserved, in several families, ancient broaches of rich workmanship, and highly ornamented. Some of them are inscribed with characters to which particular virtues were attributed, and seem to have been used as a sort of amulet or talisman.

Broad Piece; a denomination that has been given to some English gold pieces broader than a guinea, particularly Caroluses and Jacobuses.

Broadside, in a naval engagement; the whole discharge of the artillery on one side of a ship of war, above and below. A squall of wind is said to throw a ship on her broadside, when it presses her down in the water, so as nearly to overset her.

Broad-Sword; a sword with a broad blade, designed chiefly for cutting, used by some regiments of cavalry and Highland infantry in the British service. It has, in general, given place to the sabre among the cavalry. The claymore or broad-sword was formerly the national weapon of the Highlanders.

Brocade; a stuff of gold, silver, or silk, raised and enriched with flowers, foliage and other ornaments. Formerly, it signified only a stuff wove all of gold or silver, or in which silk was mixed; at present, all stuffs, grograms, satins, taffetas and lustrings are so called, if they are worked with flowers or other figures.

Brome; a peculiar substance discovered in 1826. It is obtained from the bittern of sea-water, or the washings of the ashes of sea-weed. It is a dark-red liquid, of a specific gravity of 2.965, highly volatile, and emits copious red fumes at the ordinary temperature of the air. It boils at 116°. The vapour does not sustain the combustion of a candle, though several of the metals burn in it. It possesses the bleaching powers of chlorine, and, like that substance, is eminently hostile to life; a single drop of it placed upon the bill of a bird being sufficient to kill it. With oxygen and hydrogen it forms acids. Its properties have led to the opinion, that it might be a compound of chlorine and iodine; but as neither of these substances have been detected in it, we are, for the present at least, obliged to regard it as a simple element.

Bronchant, in *Heraldry*; a term used by the French heralds to denote the situation of any beast, when placed on a field strewed with fleurs-de-lis.

Bronchia, in *Anatomy*; the two primary divisions of the trachea or windpipe, which convey the air to the lungs.

Bronchial Arteries arise from the descending aorta, and accompany the bronchiæ into the lungs.

Bronchial Glands; absorbent glands situated at the root of the lungs.

Bronchial Veins are those which accompany the bronchial arteries.

Bronchotomy, in *Surgery*; the operation of cutting into the trachea or windpipe.

Bronchus, in *Anatomy*, properly denotes the lower part of the aspera arteria, dividing into bronchiæ, or branches.

Bronzes; works of art cast in bronze. The ancients used bronze for a great variety of purposes; arms and other instruments, medals and statues, of this metal, are to be found in all cabinets of antiquities. Egyptian idols of bronze are contained in the British Museum. The most celebrated antique bronze statues are, the sleeping satyr; the two youthful athletes; the colossal equestrian statue of Marcus Aurelius, at Rome; the Hercules of the capitol; the colossal head of Commodus; the statue of Septimius Severus in the Barberini palace. The horses of St. Mark, at Venice, are of pure copper. On tables of bronze were inscribed laws, edicts, and treaties. 3000 of these were destroyed by fire in the time of Vespasian. Bass-reliefs, vaults, and doors of public edifices, were ornamented with decorations of the same metal. Urban VIII. took from the Pantheon alone 450,000 pounds of bronze, which he used for the ornaments of St. Peter's, and for the cannon of the castle of St. Angelo. One of these was composed wholly of bronze nails, taken from the portico, and bore the inscription, *Ex clavis trabalibus porticûs Agrippæ*. The ancients considered this metal as naturally pure; all their instruments of sacrifice, and sacred vessels, were therefore of bronze. They also believed it endowed with the power of driving away spectres and malignant spirits. The words *moneta sacra* are found only on bronze medals. It was sacred to the gods; and the Roman emperors, who struck gold aud silver coins, could not strike them of bronze without the permission of the senate; hence the inscription S. C. (*Senatus consulto.*) The moderns have also made much use of bronze, particularly for statues exposed to accidents, or the influence of the atmosphere, and for casts of celebrated antiques. The moulds are made on the pattern, of plaster and brick-dust. The parts are then covered on the inside with a coating of clay as thick as the bronze is intended to be. The mould is now closed, and filled on its inside with a nucleus or core of plaster and brick-dust, mixed with water. When this is done, the mould is opened, and the clay carefully removed. The mould, with its core, are then thoroughly dried, and the core secured in its position by bars of bronze, which pass into it through the external part of the mould. The whole is then bound with iron hoops, and the melted bronze is poured in through an aperture left for that purpose: of course, the bronze fills the same cavity which was occupied by the clay, and forms a metallic covering to the core. It is afterwards made smooth by mechanical means.

Bronzing. Bronze of a good quality acquires, by oxidation, a fine green tint, called *patina antiqua*, or, by the Romans, *ærugo*. Corinthian brass receives in this way a beautiful green colour. This appearance is imitated by an artificial process, called *bronzing*. A solution of sal ammoniac and salt of sorrel

in vinegar is used for bronzing metals. Any number of layers may be applied, and the shade becomes deeper in proportion to the number applied. For bronzing sculptures of wood, plaster, figures, &c., a composition of yellow ochre, Prussian blue, and lampblack, dissolved in glue-water, is employed.

Brown; a dusky kind of pigment, inclining somewhat to redness.

Bruiser, in *Mechanics;* the name of a concave tool used for grinding and polishing the specula of telescopes. It is made of brass, about a quarter of an inch thick, and hammered as near to the gauge as possible. It is tinned on the convex side, and made equally broad at bottom and top. This serves to reduce the figure of the grinding stones, when they are too convex, and to rub down any gritty matter that happens to be mixed with the putty, before the speculum is applied to the polisher.

Bruising, in *Pharmacy;* the operation of breaking or pounding a thing coarsely, or by halves; frequently practised on roots, woods, and other hard bodies, to make them yield their juice more freely than they would do in their natural state.

Buccinator Musculus, in *Anatomy,* arises from the alveolus, containing the last grinder of the lower jaw; from the coronoid process, and from the tubercle behind the socket of the last grinder of the upper jaw; its fibres proceed over the membrane of the mouth, where it lines the cheek, and terminates in both the lips and in the angle of the mouth. It draws the lips backwards towards its posterior attachments, and when the lips are made fixed parts by the action of the obicularis oris, it will thrust any matter intervening between the cheek and the cavity of the mouth, into that cavity, for the purposes of mastication and deglutition.

Buccula, in *Anatomy;* the fleshy part under the chin.

Bucking. See Bleaching.

Buffet; anciently, a little apartment, separated from the rest of the room, for the disposing of china, glass, &c. It is now a piece of furniture in the dining-room, called also a *side-board,* for the reception of the plate, glass, &c. In France, the principal houses have a detached room, called *buffet,* decorated with pitchers, vases, fountains, &c.

Buffone (*Italian*); buffoon; a comic singer in the *opera buffa,* or the Italian *intermezzo.* The Italians, however, distinguished the *buffo cantante,* which requires good singing, from the *buffo comico,* in which there is more acting. *Buffoonery* is the name given to the jokes which the buffoon introduces. The word is, no doubt, borrowed from the Low Latin, in which the name *buffo* (cheeked), was given to those who appeared on the theatre with their cheeks puffed up, to receive blows on them, and to excite the laughter of the spectators. Hence *buffa,* cheeks; *buffare,* to puff up the cheeks. Afterwards, the name came to signify a *mimic,* a *jester* in general.

Bugle-Horn. See Horn.

Building Materials. Our article on Bricks contains a general view of the best modes of preparing argillaceous earths for the purposes of building. There are however other materials, which must be noticed here. We may commence with stone, which is a dense, coherent body of considerable hardness and durability, but generally brittle. It possesses these qualities, in various degrees, according to the nature of its chemical elements, or the state of aggregation of its parts.

The structure of stone is either laminated, or granulated, or of a mixed kind.

The chemical constituents of building stones, are silica, alumina, lime, magnesia, and metals, combined with acids, water, and sometimes with alkalies: some other chemical elements are found in building stones, but not often in sufficient quantity to affect the nature of the stones.

Laminated stones consist of thin plates, or layers, cohering more or less strongly together; when the layers are of considerable size, and cohere so slightly that they may be easily separated, the stones are said to be slaty. The layers are always nearly parallel to the quarry-beds of the stones, and they should always be horizontal, or as nearly so as possible in a building; otherwise the action of the weather will cause them to separate, and fall off in flakes. In sand stones, the direction of the layers may often be discovered by their different shades of colour; in others by the positions of minute scales of mica, which always lie parallel to the layers. In most stones the direction of the layers may be ascertained by the facility with which the stone yields to the tool in that direction; but a considerable degree of practice is necessary to acquire so nice a discrimintion of resistance, and good workmen only attain it. Among laminated stones, those are the most durable in which the laminæ are least distinct, and the texture uniform. When the laminæ do not perfectly cohere, they are soon injured by frost, and they are wholly unfit for places alternately wet and dry,

Granular stones consist of distinct concretions resembling grains, either of the same, or of different simple minerals cohering together. When the structure is uniform, and the grains or concretions are small, stones of this kind are always strong and durable, if the concretions themselves be so. Granular stones are sometimes open and porous, but when they are uniformly so, they seldom suffer materially by frost; because their uniform porosity allows the expansive force of congealing water to be distributed in every direction.

Stones of a compound structure, partly laminated and partly granular, have more or less of the characters of the two classes before described; for it may be observed in coarse-grained granite that the laminated structure of some of its parts renders it very susceptible of disintegration. All kinds of stone obtained from quarries are found divided by vertical or inclined seams, which are sometimes so close that they cannot be distinguished till the stones are wrought; but they often separate under the tool at such seams; and it is not safe to employ stone to resist any considerable transverse strain, on account of the difficulty of knowing where those seams are.

In the present state of our knowledge of this important subject, we may attribute the failure of building stones to two causes; the one chemical, and the other mechanical, which we shall here distinguish by the terms *decomposition* and *disintegration.*

Decomposition consists in the chemical elements of a stone entering into new combinations with water, oxygen, or carbonic acid gas. Stones containing such elements as are readily acted upon by these external causes will be found most subject to decompose; and the process will be, in many kinds, much hastened by a loose texture.

Stones containing saline matter, as the felspar of some granites, are acted upon by water; particularly where the soluble salt is in considerable proportion; and in some stones the application of salt water soon destroys them. Dolomieu says, the houses at Malta are built with a fine-grained limestone, of a loose and porous texture, which speedily moulders away when it has been wetted with sea-water.

Stones containing iron, which is not in a maximum state of oxidation, are often destroyed by the absorption of oxygen and carbonic acid; the presence of moisture accelerates their decomposition, and it is always still farther hastened by increasure of temperature. According to the observations of Kirwan, stones containing iron in a low state of oxidation are of a black, a brown, or a bluish colour; and in some instances, when united with alumina and magnesia, they are of a gray; the former, as they become more oxygenized, change to purple, red, orange, and finally pale yellow; the latter become at first blue, then purple, red, &c. (Kirwan's *Geological Essays*, p. 145, 6.) But stones containing iron, combined with its maximum of oxygen, do not readily decompose, such as red porphyry, jaspers, &c. When stones contain magnese, lime, alumina, carbon, or bitumen, in particular states, they are subject to decomposition, from the affinities of one or other of these bodies; but nothing very decisive is, or perhaps can be, known respecting such changes, till some improvement be made in analytical chemistry, by which the state of combination of the constituents of minerals can be determined with more certainty.

Disintegration is the separation of the parts of stones by mechanical action. The chief cause is the congelation of water in the minute pores and fissures of stones, which burst them open, or separate small parts according as the structure is slaty or irregularly granulated. The south sides of buildings, in northern climates, are most subject to fail; because the surface is often thawed and filled with wet in the sunny part of the day, and frozen again at night. This repeated operation of freezing is also very injurious to sea walls, the piers of bridges, and other works exposed alternately to water and frost. An illustration of this fact will be found in the bridges crossing the Thames at Westminster and Blackfriars, as the materials of which they are composed may readily be detached in the winter season by the slightest external force.

Proportional strength of various subtances in bearing pressure.—Fine freestone, 1; alder, ash, birch, white fir, willow, 6; lead $6\frac{1}{4}$; beech, cherry, hazel, $6\frac{3}{4}$; red fir, holly, elder, plane, apple, 7; walnut, thorn, $7\frac{1}{2}$; elm, ash, $8\frac{1}{2}$; box, yew, plumb-tree, oak, 11; bone, 22; brass, 50; iron 107. These results, however, differ materially from some others.

A yard of oak, an inch square, will bear in the middle, for a very short time, 330 pounds; but, according to Emerson, a third or fourth of this is as much as can be applied in practice. *Mech.* p. 114. It is in fact much more; for, in general, the weight supported ought not to produce a sensible bending; and this practical limit requires more attention than it has hitherto received. Allowance must also be made for the occasional depredations of insects.

Wood is from 7 to 20 times weaker transversely than longitudinally. It becomes stronger both ways when dry.

A cylinder, an inch in diameter, will bear, when loaded to $\frac{1}{4}$ of its whole strength, if of fir, 8.8 cwt.; if of rope, 22 cwt.; if of iron, 6.75 tons, or 135 cwt.

Count Rumford found the cohesive strength of a cylinder of iron, an inch in diameter, 63,466 or 63,173 pounds, the mean 63,320. *Phil. Trans.* 1797. This is only 1-20th more than Emerson.

In Buffon's experiments, b, d, and l being the breadth, depth, and length of a beam of oak in inches, the weight which broke it, in pounds, was $b\,d^2 \left(\frac{54.25}{l} - 10\right)$.—*Robison.*

A piece of sound oak, an inch square, bears 8000 pounds directly, and is broken transversely by 200, at the distance of 12 inches from the fulcrum. Iron is not cheaper than wood of equal strength. The immediate transverse strength of lateral adhesion of most substances exceeds their direct cohesive strength, but the difference is less in fibrous substances than in others.—*Robison.* Coulomb found them nearly equal.

Six of the pieces of oak employed in Girard's experiments broke under the pressure of 2710 pounds on a square inch at a mean, but fifteen others supported a much greater load.

A rib of cast iron, with abutments of $29\frac{1}{2}$ feet span, 11 inches high in the centre, supported 11,130 pounds, but sunk $3\frac{5}{8}$ inches, and rose again three-quarters of an inch; without abutments it broke with 6174 pounds. Bars of iron, one inch square and three feet long, weighing nine pounds, sunk about an inch, and broke with 960 pounds.

If a piece be spliced on a divided beam, equal in depth to half the depth of the beam, the strength is greater than that of the entire beam, in the ratio of 1 to 0.54, very nearly.

Coulomb found the lateral cohesion of brick and stone only $\frac{1}{11}$ more than the direct cohesion, which, for stone, was 215 pounds for a square inch; for good brick, from 280 to 300. Supposing this lateral cohesion constant, a pillar will support twice as much as it will suspend, and its angle of rupture will be 45 degrees. From the same supposition it may inferred, that the strongest form of a body of given thickness for supporting a weight, is that of a circle, since the power of the weight in the direction of every section varies as the length of that section, and the strength is therefore equal throughout the substance. But if the cohesion be increased, like friction, by pressure, and supposing, with Amontons, that this increase, for brick, is three-fourths of the weight, the plane of rupture of a prismatic pillar will form, according to Coulomb, an angle of 63° 26′ with the horizon, and the strength will be doubled. On both suppositions the strength is simply as the section. It is of the less consequence to investigate the lateral pressure of soft materials, as they are generally liable to be penetrated by water, which acts according to the laws of hydrostatics.

Supposing the pressure of the materials to be vertical only, a quadrant of a circle will support a horizontal road in equilibrio, if the depth of the bridge in the middle be to the radius as 1 to $6\frac{1}{4}$, that is, about one-ninth of the span. *Emers. Mech.* But this appears to be only an approximation.

A catenaria will support a horizontal road 100 feet above it, if the height and half the span be each 150. A logarithmic curve will form a half arch of equilibrium, if the road be horizontal. *Emerson.* But all these proportions would make the bridge too heavy.

Perronet thinks that a bridge of 500 feet span might stand; the bridge of Nantes having sunk to a radius of 500 feet.

In the construction of bridges, Professor Robison observes, that something is to be allowed for the lateral pressure of the materials; and that the cohesive strength of the arch, and its resistance to any force in the manner of a lever, ought to be taken into the calculation. These remarks are extremely just, but they do not appear to have been practically considered, except so far as theory has been modified by experience.

If there be an arch composed of stones of a given magnitude considered as perfectly solid, the effect of a weight bearing on the key-stone will be a displacement of the pressure on the abutment; the centre of pressure on the abutment will be removed to a distance, which is to the height of the arch nearly as the tangent of the immediate change of the direction of the new compound thrust of the key-stone to the radius. It seems to be desirable that this displacement should never exceed the limits of the abutments themselves.

Supposing the pressure of the materials vertical only, the curve may be constructed mechanically, without difficulty, by making the centre of each portion of it at a distance below the arc which is inversely as the distance of the arc from the road. In the case of a horizontal road, the greatest curvature will be where this distance is a mean proportional between the radius of curvature at the vertex and the depth of the materials at the same point. The following is a table of the cohesive force of building materials:

Names of Substances.	Cohesive force of a square inch in lbs. Avoirdupois.
Brick	0.300
Marble, white	9.000
Mortar, 16 years old	0.050
Plaster of Paris	0.072
Slate, Welsh	12.800
Stone, Givry, hard	2.166
———, soft	0.385
——, Portland	0.784
——, homogeneous, white, of a fine grain	0.207

BULIMIA. The persons attacked by this disorder are tormented with an insatiable hunger. When their stomach is surfeited, they are seen to faint, and throw off the food which they have taken, half digested, and with violent pain. It usually appears as a concomitant of other diseases. It occurs during certain intermittent fevers, in certain diseases of the stomach and bowels, particularly in such as are produced by the tape-worm; and is also common after fevers, by which the strength of the patient is exhausted. In this last case, it arises from the effort of all parts of the body to supply the lost flesh and strength. In certain cases, however, the extraordinary desire for food seems to be caused by a particular condition of the stomach, which digests with too great rapidity. This is observed sometimes in women during their pregnancy, in young people who exercise too violently, and in persons who take much high-seasoned and heating food. In this case, the desire is not to be considered as a disease, but only as an excessive appetite. As a disease, its consequences are dreadful—leanness, pulmonary fevers, consumption, constipation, dropsy.

BULK-HEADS; certain partitions or walls built up in several places of a ship between two decks, either lengthwise or across, to form and separate the various apartments.

BULL, in *Astronomy;* the constellation Taurus.

BULLET, an iron or leaden ball, or shot, wherewith fire-arms are loaded.

BULLION is uncoined gold or silver, in bars, plate, or other masses. The word *bullion* was of frequent use in the proceedings respecting the Bank of England (see BANK), from 1797, when the order of council was issued, that the Bank should discontinue the redemption of its notes by the payment of specie, to 1823, when specie payments were resumed; for, by a previous law, the Bank was authorized to pay its notes in uncoined silver or gold, according to its weight and fineness. The investigations of the bullion committees, and the various speculations on the subject of bullion, related to the supply of gold and silver, whether coined or not, as the basis of the circulating medium.

BULWARK. See BASTION.

BUM-BOAT; a small boat used to sell vegetables, &c., to ships lying at a distance from shore.

BUNGALOW; an East Indian term for a house with a thatched roof.

BUNT; the middle part or cavity of the principal square-sails, as the main-sail, fore-sail, &c. If one of them be supposed to be divided into four equal parts, from one side to the other, the two middle divisions, which comprehend half of the sail, form the limits of the bunt.

BUNTING; a thin woollen stuff, of which the colours and signals of a ship are usually formed.

BUOY; any floating body employed to point out the particular situation of any thing under water, as of a ship's anchor, a shoal, &c.—The *can* buoy is of a conical form, and painted with some conspicuous colour; it is used for pointing out shoals, sand-banks, &c.—The *cask* buoy is in the form of a cask; the larger are employed for mooring, and are called *mooring* buoys; the smaller for cables, and are known as *cable* buoys. The buoy-rope fastens the buoy to the anchor, and should be about as long as the depth of the water where the anchor lies; it should also be strong enough to draw up the anchor in case the cable should break.

BUOY, LIFE. The *life* or *safety* buoy is intended to keep a person afloat till he can be taken from the water. It should be suspended from the stern of the ship, and let go as soon as any person falls overboard. A light may be attached to it, both to indicate its position to the individual in danger, and to direct the course of the boat sent to relieve him, if the accident happens by night. Captain Basil Hall thus describes the apparatus employed in the British service:—"The life-buoy, now commonly used in the navy, is the invention of Lieutenant Coots, of the Royal Navy. It consists of two hollow copper vessels connected together, each about as large as an ordinary sized pillow, and of buoyancy and capacity sufficient to support one man standing upon them. Should there be more than one person requiring support, they can lay hold of rope beckets, fitted to the buoy,

and so sustain themselves. Between the two copper vessels there stands up a hollow pole, or mast, into which is inserted, from below, an iron rod, whose lower extremity is loaded with lead, in such a manner, that when the buoy is let go, the iron slips down to a certain extent, lengthens the lever and enables the lead at the end to act as ballast. By this means the mast is kept upright, and the buoy prevented from upsetting. The weight at the end of the rod is arranged so as to afford secure footing for two persons, should that number reach it; and there are also, as I said before, large rope beckets through which others can thrust their head and shoulders, till assistance is rendered.

"At the top of the mast is fixed a port-fire, calculated to burn about twenty minutes, or half an hour; this is ignited most ingeniously by the same process which lets the buoy fall into the water. So that a man falling overboard at night is directed to the buoy by the blaze on the top of its pole or mast, and the boat sent to rescue him also knows in what direction to pull. Even supposing, however, the man not to have gained the life-buoy, it is clear that, if above the surface at all, he must be somewhere in that neighbourhood; and if he shall have gone down, it is still some satisfaction, by recovering the buoy, to ascertain that the poor wretch is not left to perish by inches.

"The method by which this excellent invention is attached to the ship, and dropped into the water in a single instant, is perhaps not the least ingenious part of the contrivance. The buoy is generally fixed amid ships, over the stern, where it is held securely in its place by being strung, or threaded, as it were, on two strong perpendicular rods fixed to the taffrail, and inserted in holes piercing the frame-work of the buoy. The apparatus is kept in its place by what is called a slip-stopper, a sort of catch-bolt or detent, which can be unlocked at pleasure by merely pulling a trigger; upon withdrawing the stopper the whole machine slips along the rods, and falls at once into the ship's wake. The trigger, which unlocks the slip-stopper, is furnished with a lanyard, passing through a hole in the stern, and having at its inner end a large knob, marked 'Life-Buoy;' this alone is used in the day-time. Close at hand is another wooden knob, marked 'Lock,' fastened to the end of a line, fixed to the trigger of a gun-lock primed with powder, and so arranged that, when the line is pulled, the port-fire is instantly ignited, while, at the same moment, the life-buoy descends, and floats merrily away, blazing like a light-house.

"The gunner, who has charge of the life-buoy lock, sees it freshly and carefully primed every evening at quarters, of which he makes a report to the captain. In the morning the priming is taken out, and the lock uncocked. During the night a man is always stationed at this part of the ship, and every half-hour, when the bell strikes, he calls out 'Life-Buoy!' to show that he is awake and at his post."

Burbas, in *Commerce;* a small coin still circulated at Algiers, with the arms of the Dey struck on both sides, worth half an asper.

Burden, or Burthen; 1. the contents of a ship; the quantity or number of tons which a vessel will carry; 2. the part of a song which is repeated at every verse or stanza, is called the *burden of the song*, from the French *bourdon*, drone or base, because they are both characterized by an unchangeable tone, and bear upon the ear with a similar monotony.

Bureau; a writing-table; afterwards used to signify the chamber of an officer of government, and the body of subordinate officers who labour under the direction of a chief. *Bureau system*, or *bureaucracy*, is a term often applied to those governments in which the business of administration is carried on in departments, each under the controul of a chief; and is opposed to those in which the officers of government have a co-ordinate authority. Sometimes a mixture of the two systems is found. Thus the business of the executive branch of government may be carried on by bureaus, while the administration of justice is in the hands of co-ordinate judges. The *bureau des longitudes*, in France, corresponding to the English *board of longitude*, is charged with the publication of astronomical and meteorological observations, the correction of the astronomical tables, and the publication of the *Connaissance des Temps*, an astronomical and nautical almanac. (See Almanac in our *Second Division*.) According to the parliamentary usage of France, at the opening of each session, the chamber of deputies is divided into nine *bureaus*, composed of an equal number of deputies, designated by lot. Each bureau appoints its own president, and discusses all matters referred to it by the chamber separately. A reporter is appointed by each bureau, and, after the discussion by bureaus, the nine reporters meet, discuss the subject, and appoint one of their number to report to the whole chamber, where the final discussion and decision of the subject takes place. See *Réglement pour la Chambre des Députés*, Paris, 1827.

Burgundy Wines are produced in the former provinces of Upper and Lower Burgundy, in a soil of a light-black or red loam, mixed with the *débris* of the calcareous rock on which it reposes. In richness of flavour and perfume, and all the more delicate qualities of the juice of the grape, they are inferior to none in the world. It is to the great skill with which the cultivation of the vine and the fermentation of the liquor are managed, that they owe those generous qualities, which gave to the dukes of Burgundy the title of *princes des bon vins*, and which, as Petrarch more than hints, contributed not a little to prolong the stay of their holinesses at Avignon. They are remarkable for their spirituosity and powerful aroma, and are therefore more heating than some other wines which contain more alcohol. The exhilaration they produce is, however, more innocent than that resulting from heavier wines. The finer wines of Burgundy do not bear removal except in bottles; and as they are not produced in great abundance, they are rarely, if ever, met with in foreign countries. It is the inferior growths which are sold under that name. The Burgundy wines are generally exported between January and May, chiefly in double casks. They keep only four or five years, and are very apt to acquire a bitter taste, which Chaptal attributes to the developement of the acerb principle, and Henderson to that of citric ether. It may sometimes be partially removed by new sulphuring and fining. The most numerous are the red wines of Burgundy. The finest growths of these are the Romanée-Conty, the Chambertin (the favourite of Louis XIV. and Napoleon), the Closbougeot, the Rhichebourg, the Romanée de St. Vivant, &c. They are distinguished for their beautiful colour and ex-

quisite flavour and aroma, combining more than any other wines, lightness and delicacy, with richness and fulness of body. Of the second class are the *vins de primeur*, of which the Volnay and Pomard are the best; those of Beaune, distinguished above all by their pure flavour, and formerly considered the most choice of the Burgundy wines; the Macon wines, remarkable for their strength and durability; those of Tonnerre and Auxerre, &c. The white wines of Burgundy are less numerous, but not inferior in aroma and flavour. The famous Montrachet is equal to the finer red wines, and is distinguished for its agreeable nutty flavour. Of the second class are the *Goutte d'or*, so called from the splendour of its tint; La Perrière, &c. See Jullien's *Classification des Vins*, and Henderson's *Ancient and Modern Wines*.

Burin, or Graver; an instrument of tempered steel, used for engraving on copper. It is of a prismatic form, having one end attached to a short wooden handle, and the other ground off obliquely, so as to produce a sharp point. In working, the burin is held in the palm of the hand, and pushed forward so as to cut a portion of the copper. The expressions *brilliant* burin, *soft* burin, are used to characterize the manner of a master.

Burning-Glass; a lens which unites the rays of light that fall upon it in so narrow a space as to cause them to kindle any combustible matter coming in their way like fire. The same name has been sometimes given, though improperly, to the burning-mirror. The lenses commonly used as burning-glasses are convex on both sides; these bring the rays upon a point with the greatest force, because of the shortness of their focal distance. The effects of a burning-glass are more powerful in proportion as its surface is greater, and its focus smaller. That such a glass may produce its greatest effect, it is necessary that the rays of the sun should fall upon it in a perpendicular direction, which is the case when the image of the sun, that appears at the moment of burning, is circular. If a second lens, of a smaller focal distance, is placed between the first and its focus, so as to intercept the rays which pass through the first, they are still more condensed, and united in a still narrower compass, so that the effect is greatly augmented. The Greeks and Romans seem to have been acquainted with burning-glasses, or at least with a kind of transparent stones similar to them. They became more known in the 13th century. At the close of the 17th, von Tschirnhausen caused the largest burning-glasses, consisting of one piece, that are known, to be polished with incredible pains. Two of them, still in Paris, are 33 inches in diameter, and the weight of one amounts to 160 pounds. Both glasses produce an effect equal to that of the most intense fire. They kindle wood, which is both hard and wet in a moment, and make cold water, in small vessels, boil in an instant; metals placed upon a plate of china, are melted and vitrified by them; tiles, slates, and similar objects, become instantly red-hot and vitrified. As Tschirnhausen's glasses, however, are not perfectly clear, and the effect is thus considerably lessened, Brisson and Lavoisier undertook, in 1774, to put together two lenses, resembling those used for watch-glasses, filling up the space between them with a transparent fluid. In this manner, veins and impurities may be avoided at less expense. They succeeded in making a burning-glass of 4 feet in diameter, the greatest thickness of which, in the centre, amounted to 8 inches, and which of itself had a much greater power than the glasses of Tschirnhausen, in connection with a smaller lens, or collective glass, but produced an extraordinary effect if joined to a collective glass. The experiments made by means of large burning-glasses are important in chemistry and physics. The power of a burning-glass, however, is almost four times less than that of a burning-mirror or reflector, of equal extent and equal curvature. This reflects more light than the glass allows to pass through it; has a smaller focal distance, and is free from the dissipation of the rays which takes place in the burning-glass, since it reflects them all nearly to one point, while the burning-glass refracts them to different points. On the other hand, the burning-glass is much more convenient, on account of the place of its focus, which is behind the glass. The burning point (focus) is an image of the sun; its diameter is equal to the 108th part of the focal distance, and its centre is the *focus*, properly so called. In the higher branches of geometry and conic sections, the *foci* are points in the parabola, ellipsis, and hyperbola, where the rays reflected from all parts of these curves meet. Several accidents in modern times have shown that conflagrations may be caused by convex window-glasses or water-bottles, &c., which have the form of burning-glasses, if the rays of the sun are concentrated by them upon combustible substances lying within their reach. Since the casting and polishing of large lenses are attended with great difficulties, Sir David Brewster's plan of casting them in pieces, or zones, and afterwards putting them together, has lately been practised. Lenses of this last kind have been ingeniously applied, by Becquey, for augmenting the light on light-houses, according to the suggestion of Fresnel. (See Pharos.) For the history of burning instruments, see the article Burning-Mirrors.

Burning-Mirrors, or Reflectors; mirrors, the smoothly polished surface of which reflects the rays of the sun that fall upon it in such a direction, that they unite at some distance from the mirror, in a more limited space, and act upon substances within this space like the most powerful fire. Concave mirrors cause the rays that fall upon them in a direction parallel to their axes to converge. Spherical mirrors of this kind are the most common; but parabolic ones are also used; and even plane mirrors may be employed like concave ones, if several of them are combined in a proper manner. In order that a burning-mirror should produce its whole effect, its axis must be directed exactly towards the centre of the sun's disc. This is the case if the light, intercepted by a plane, perpendicular to the axis of the mirror, at its focal distance, forms a circle. The focus then lies in a straight line between the sun and the mirror. The ancients were acquainted with such mirrors, as is manifest from several of their writings still extant. It is impossible, from the nature of things, that Archimedes, during the siege of Syracuse by Marcellus, should have set on fire the fleet of the latter by means of concave mirrors: it would be more credible, that it had been effected by a combination of plane mirrors. Various experiments have shown that great effects may be produced, at a considerable distance, by the latter instrument. Kircher placed five plane mirrors, of an equal size, in such a

position as to reflect the rays upon a spot one hundred feet distant, and thereby produced a great heat. Buffon, in 1747, effected a combination of 168 plane mirrors, each of which was 6 inches broad, and 8 long. With forty of these mirrors, he set on fire almost instantaneously a board of beech wood, covered with tar, at a distance of 66 feet; and with 128 mirrors, a board of pine wood, likewise covered with tar, at a distance of 150 feet. With 45 mirrors, he melted a tin bottle at a distance of 20 feet, and with 117 mirrors, small pieces of money. He afterwards burned wood with this machine, at the distance of 200 feet, melted tin at the distance of 150, lead at the distance of 130, and silver at the distance of 60 feet. During the last century, several large mirrors were made in Italy, two of which are still in Paris and Cassel. Von Tschirnhausen also manufactured one in 1687, 3 Leipsic ells (about $5\frac{1}{2}$ English feet) in diameter, and the focal distance of which was 2 ells ($3\frac{7}{10}$ English feet.) It consists of a thin plate of copper, highly polished, and is now in the mathematical hall in Dresden. This mirror sets wood on fire, makes water boil, melts tin three inches thick, as well as lead, vitrifies bricks, bones, &c. Besides metals, wood, pasteboard, glass, and other materials, serve for burning-mirrors, if their surface be polished. Burning mirrors have of late been used as reflectors to throw light at a great distance, and may be very usefully employed in light-houses. If, for instance, a lamp is placed in the focus of a parabolic mirror, the rays of light which fall on it are all reflected in a direction parallel to the axis; thus the reflectors of Lenoir appear like stars of the first magnitude at the distance of 80,000 feet. (For farther information on burning-glasses and burning-mirrors, see Priestley's *History and Present State of Optics;* and the 5th vol. of the new edition of Gehler's *Physikalisches Lexicon*, Leips. 1825.)

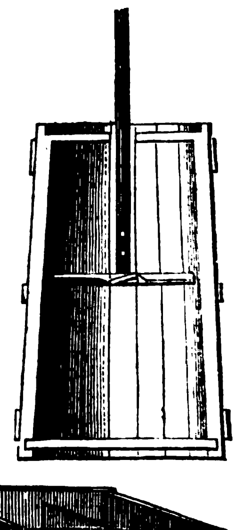
Burnisher is a blunt, smooth tool, used for smoothing and polishing a rough surface by pressure, and not by removing any part of the body. Other processes of polishing detach the little asperities. Agates, tempered steel, and dogs' teeth, are used for burnishing. It is one of the most expeditious methods of polishing, and one which gives the highest lustre. The burnishers used by engravers are formed to burnish with one end, and to erase blemishes with the other.

Bursa Mucosa, *in Anatomy*, is an apparatus for facilitating the motion of the muscles and tendons upon these parts.

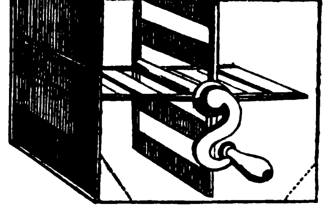
Bushel; an English dry measure, containing 8 gallons or 4 pecks. It is also used in the North American United States. The standard English bushel (12 Henry VII.) contained 8 gallons of wheat, each of 8 pounds troy, each of 12 ounces, each of 20 pennyweights, each of 32 corns of wheat that grew in the middle of the ear. In 1696, a duty being laid upon malt, it became necessary to ascertain the exact contents of the *Winchester bushel*, as that of Henry VII. was called. It was found that the capacity was 2151.7 cubic inches of pure water, equivalent to 1131 oz., 13 dwts. troy. (See J. Q. Adams's *Report upon Weights and Measures*, Washington, 1821.) The capacity of the *Imperial bushel*, prescribed by the act of uniformity (5 Geo. IV. c. 74), which took effect, January 1, 1826, is for coal, potatoes, fruits, and other goods sold by *heaped measure*, 2815 cubic inches, the goods to be heaped up in the form of a cone, to a height above the rim of the measure of at least three-fourths of its depth. The imperial bushel for all liquids, and for corn and other dry goods *not heaped*, contains 2218.20 cubic inches, and holds 80 lbs. avoirdupois of pure water.

Bust (Italian, *il busto*, from the Latin *bustum*), in *Sculpture;* the representation of that portion of the human figure which comprises the head and the upper part of the body. Busts are of different extent: 1. such as consist of the head, the upper part of the neck, and the upper part of the shoulders; 2. heads with the upper part of the chest, to the end of the breast-bone (*busts* properly so called); and 3. heads with the whole chest to the middle of the body, often to the hips. Between the bust and its pedestal is sometimes a column, or a square prop; such a bust is called *Herme*. The figure is sometimes in relief. The origin of the bust may be derived from the Herme, and from the custom of the Greeks and Romans to decorate their shields with portraits, and their vestibules with the images of their ancestors. Busts were afterwards used for the images of their gods, as being less expensive. The greater part have been found in Rome and Italy. Some remarkable ones have been obtained from Herculaneum in bronze. The chief difficulty in the execution of busts arises from this circumstance, that we are accustomed to estimate the size of the head by comparing it with the whole body. In a bust, therefore, the head appears disproportionately large, and the artist is obliged to yield, in some measure, to this ocular deception, by lessening its natural proportion.

Butter; an oily substance, produced from the milk of kine. *Cream* is composed of an oily substance, a caseous matter, and serum or whey. If it be agitated for a given period in a churn, a separation of these parts takes place, and a solid, called *butter*, and a liquid, called *butter-milk*, consisting of the whey, are the products.



The common butter churn is represented in the annexed engraving, consisting of a plunger or flat piston, put in motion in a perpendicular direction, which by agitating the cream, separates the butter from the thin fluid.



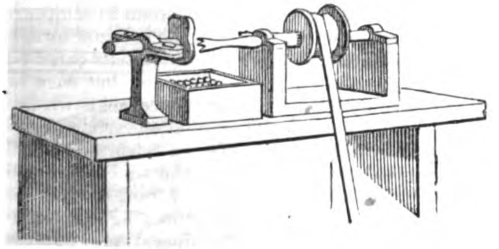
Turning from this primeval instrument, we come to a box machine with a series of plungers revolving in the opposite direction, which will usually separate the chemical constituents of the milk, and produce butter in less than half the time required by the former instrument.

The proportions of these products in butter, in 100 parts of cream, are,

Butter	4.5
Cheese	3.5
Whey	92.0
	100.0

Chemical analysis gives stearine, elaine, and a small quantity of acid and colouring matter, as the component parts of butter. Beckmann (*History of Inventions*, 372) comes to the conclusion that butter is not of Grecian nor of Roman invention; but that the Greeks received it from the Scythians, Thracians, and Phrygians, and that the Romans derived it from the people of Germany, and used it as a medicine, rather than as a culinary luxury. In warm countries, the place of butter is still, for the most part, supplied by oil. In Italy, Spain, Portugal, and the south of France, it is to be purchased in the apothecaries' shops. The difficulty of keeping it any length of time is, indeed, an effectual barrier to its general use. The ancients appear to have been wholly deficient in the art of giving it consistency. The European countries in which oil or butter is used, says Malte-Brun (*Géog.* liv. xcv.), may be separated by a line extending along the Pyrenees, the Cevennes, the Alps, and Mount Hæmus. To the north the pasturage is better; cattle abound, and the food is chiefly derived from them. The butter, beer, and animal food of the north of Europe, give way to oil, wine, and bread, in the warmer regions. The word *chameah*, translated *butter*, in the English version of the Bible, means some liquid preparation of milk or cream. It was in general use among the Celts:—*Spuma id est lactis, concretiorque quam quod* serum *vocatur, barbararum gentium lautissimus cibus*. (*Pliny*, ix. 41, and xxviii, 9). The Hindoos make use of *ghee*, which means butter clarified by boiling. They boil the milk two or three hours, which, when cool, is fermented with curdled milk, left to sour, churned, and when it is sufficiently rancid, is boiled and mixed with salt, or betel-leaf and ruddle, to improve its taste and colour.

Buttons are of almost all forms and materials—wood, horn, bone, ivory, steel, copper, silver, similor, &c. The tailor covers them with stuffs, and the female artisan envelopes them with a texture of thread, silk, cotton and gold or silver thread. The non-metallic buttons, called also *moulds*, are made of the substances first mentioned, by sawing them into little slips of the thickness of the button to be made.



The most curious part of button-making consists in the simple machine or lathe by which the material is cut into a round form. It is represented above, and consists of two thin knives on a pointed axis, the whole of which revolves, and thus cuts the circular disc. The holes are afterwards drilled in a similar lathe, provided with four axes turning from a wheel, which is put in motion by the foot of the workman.

Metallic buttons are cast in moulds, or cut by a fly-press. Any figure or inscription may be impressed on them at the same time that they are cut. The little wire ring by which they are attached to a garment, is called the *shank*, and is soldered separately on each button. The details of smoothing, polishing, boiling, &c., would occupy too much room. The face of the button is generally plated or gilt. Dr. Church, an American, obtained a patent in England (1829), for an improved manufacture of buttons with a metallic shank, the face being either of polished metal, or covered with any fabric. The various operations of shaping the discs, forming the shanks, cutting the cloth, and covering the faces of the buttons, are all effected by one revolving shaft.

Buttresses, in *Gothic Architecture*, are lateral projections on the outside of the walls of an edifice, extending from the top to the bottom, at the corners, and between the windows. They are necessary to support the walls, and prevent them from spreading under the weight of the roof.

Byzantine School of Art. After Constantine the Great had made the ancient Byzantium the capital of the Roman empire, and ornamented that city, which was called after him, with all the treasures of Grecian skill, a new period commenced in the history of art. From this time it became subservient to Christianity, as the religion of the state. All the productions of heathen artists which formed suitable ornaments for Christian cities and temples, were now employed in the service of the invisible God, and art began by slow degrees to rise from its degeneracy, under the influences of Christianity. At the time when Constantine converted Byzantium into an imperial residence, splendour and ornament had already supplanted the simplicity of ancient taste. Asiatic luxury had become predominant, and this laid more stress on richness of material and decoration than on purity of conception. Architecture which adorned the *forum Augusteum*, in Byzantium, with a fourfold colonnade, and created splendid *curiæ*, imperial palaces, baths, theatres, and porticoes, preserved for a long time the grand forms of classic times, and deviated from them slowly and gradually, at first in the Christian churches, as a model for which Justinian built the church of St. Sophia, and decorated it with Oriental magnificence, in 537. But even in architecture, the costliness and colour of the marble was soon considered as of more importance than the proportion of the parts and the distribution of the columns. There are, however, as late as the ninth century, admirable works of Greek architecture, particularly those of Theodosius the Great and Justinian. This period was still less favourable to the simplicity of sculpture. The mythology of ancient Greece afforded sacred subjects to the statuary. Gods appeared in the human form, and the human figure, in the Grecian model, was raised to the classical ideal. On the introduction of the Christian religion, sculpture was confined to the imitation of nature; afterwards to portraits, and to mere purposes of ornament; for Christianity is averse to sensible representations of the Divinity. Statues of emperors, of great statesmen and generals, became the subjects of the sculptor, and seem eventually to have given rise to the introduction of the worship of images in the Christian churches, since the custom of erecting mo-

numents and statues to the emperors and distinguished bishops, was extended to martyrs and saints, and was afterwards followed by the superstitious and impious worship of them. Though images of this kind became more frequent in the third and fourth centuries, there were yet many Christian teachers, who, like Tertullian, at an early period, declared the fine arts inventions of the devil, and the pagan statues possessed by demons. This superstition often caused the destruction of the noblest statues of the Grecian gods by popular violence. It was not until after many difficulties, that, in the ninth century, the worship of images was established in the Greek empire, and after that time appeared the first known traces of Christian sculpture and painting in the East. But even those statues to which sculpture was now confined, no longer displayed the freedom and dignity of ancient art. The pride of the emperors demanded statues of gold and silver, as long as their treasury, filled by exhausting their subjects, could supply them. Images of bronze and marble were despised. And how seldom could the artist be inspired by his subject, when flattery erected monuments and busts to the most worthless of men! It was natural, that, with the loss of elevated subjects, the dignity of art should be lost in petty technical details. Heyne, in his treatise on the later works of art, under the Byzantine emperors (*Commentat. Soc. Götting.*, vol. xi.), observes, that the representations of the emperors, of distinguished men, or of saints, were uniform in figure and character. The vestiges of genius were nowhere seen in free creations and ideal forms, in the desire of truth and expression. From the time of Justinian downwards, the true measure and proportion of the parts, and the correctness of the outlines were so much neglected, that the representations became constantly more like masks, spectres, and monsters. The old Roman faces were seldom represented: the forms appeared to belong to quite another race—to some new nation; and it was often necessary to write the names under them. In the perspective of the figures no rules were observed. It became at this time the great object to imitate the costly robes of the emperors, bishops, and other noble persons, who gratified their vanity not only with purple garments, but by the extravagant use of pearls and precious stones, which were worn in long pendants from the ear, in bracelets, and in necklaces. The whole mantle was often garnished with precious stones, and round the edge ran a double row of pearls. Such garments the emperor used to change several times a day. As such exterior ornaments are foreign from sculpture, which prefers the naked figure, or a simple drapery, it is easy to see why the production of statues ceased so soon. In the lists of Byzantine works of sculpture given by authors of the first centuries, there are no images of Christ, no statues of apostles and saints. Instead of them, we find only crucifixes, painted, or ornamented with mosaic work. If there were any such images in earlier times, they must have been destroyed in the time of the Iconoclasts, as was the case with the bronze statue of Christ, near that of Constantine, which was demolished by Leo, the general destroyer of images, and the representations of the *Good Shepherd*, praised by Eusebius, and that of *Daniel among the Lions*, with which Constantine adorned the public fountains. An image of the Saviour, surrounded by angels, and worked in mosaic, is described by Photius. We also find mention of the images of two angels upon the forum of Constantine, the representation of Adam and Eve, the bronze statue of Moses, with which Justinian is said to have ornamented the *curiæ*, and that of Solomon of an earlier date. According to Eusebius, the roof of the palace in Constantinople was also decorated with rich mosaics of gold and costly stones, representing scenes from the passion of Christ; and another, which Justinian erected, in Chalcis, contained representations of events in the war against the Vandals. The most celebrated of all the mosaics in the interior of St. Sophia's church in Constantinople has been preserved in fragments to modern times. The taste of those times inclined, in general, more to mosaic works than to sculpture; because the former were rendered attractive by the costliness and colours of the stones. Sculpture was employed particularly in ornamenting altars, tabernacles, holy vessels, and urns, which were made of the most precious marble. The art of engraving on stones was also long preserved. In the art of painting, which was imitated in mosaic, the taste of this age was the same as in sculpture—pleased with gold and lively colours, but careless about truth of representation, and beauty and grandeur of conception. The first germ of a Christian style of art was, however, developed in the Byzantine pictures. The ideal representations of human figures, which the ancient Grecian artists had exhibited in their master-works, were necessarily given up by Christian artists: another ideal was to be formed, which should not recall the odious features of paganism. But the ideal of the Saviour, of the mother of Christ, and of his apostles, could be formed only by degrees. The artists, who had nothing real and material before them, but were obliged to find, in their own imaginations, conceptions of the external appearance of sacred persons, could give but feeble sketches of their ideas by means of their imperfect art. In their representations of Jesus and his apostles, they finally adopted the national features of the Jews. In the figure, and sometimes even in the countenance, they imitated the external appearance of some revered bishop. The hands were often lifted, as in blessing, or one hand was laid upon the breast, or holding a book. Thus the figures of the founders of the Christian church were first represented in paintings. They were also exhibited in mosaic, but not in marble. Christian subjects, indeed, are generally more suited to painting, which gives the outward expression of the mind, by means of light and shade, and colours, than to sculpture, which, on the contrary, elevates the external form to a kind of spiritual dignity. As the artists cared but little for a faithful imitation of nature, but were satisfied with repeating what was once acknowledged as successful, it is not strange that certain forms, introduced by the authority of some celebrated artists, and approved by the taste of the time, should be made by convention, and without regard to truth and beauty, general models of the human figure, and be transmitted as such to succeeding times. In his treatise on the continuation of the arts in Constantinople (*Comment. Soc. Götting.* vol. xiii.), Heyne remarks, that art continued to be exercised here, as far as it consists in mechanical skill, in the use of instruments in particular rules and general precepts; but taste, and a sense for truth and simple beauty, had

vanished. Delicacy, elegance, and gracefulness in design, proportion of parts, harmony of the figures, and beauty of form were lost. The artists did not even aim at an accurate representation, but were contented with rude and general outlines, as may be seen in the coins of the time. These deformed and meagre figures were slavishly copied, and labour was lavished on costly, and often tasteless ornaments. A certain propensity to the grotesque prevailed, even in architecture. The influence of ancient works of art continually decreased as their number was diminished by the violences of war, by superstition, by avarice, and by the hand of time. Most of the then existing works of antiquity perished in the capture of Constantinople, during the crusades of 1204 and 1261; and thus the city had long been deprived of its most beautiful ornaments, when it was taken by the Turks, in 1453.—This was in general the state of art in the Byzantine empire. Its influence has been felt ever since; in earlier times, by the connection of the imperial residence in the East with the Western Empire, and afterwards by commercial intercourse and the crusades.—Let us first consider this connection of the lower Greek art with the west of Europe, and in particular with Italy. According to Stieglitz (on *German Architecture*), the character of the lower Greek architecture was tranquillity and simplicity, originating from poverty of ideas and materials, and terminating in heaviness. But this architecture, which prevailed till the earlier part of the middle ages, preserved the seed, from which in later times a new and better style sprung up. Constantinople became a school of architecture, from which artists issued to all parts of the Roman empire, as far as Britain, to erect churches after the model of St. Sophia. They also penetrated into the countries of the East, introducing their art among the Arabians, who applied it to the erection of their mosques, and among the Moors in Spain, who formed their own style from it. The lower Greek or Byzantine style kept itself pure and uncorrupted in Italy, under the Lombards, as well as under the Goths, whose artists came from the East; and thence it spread during the reign of Charlemagne, to Germany, Gaul, and England. The style of architecture introduced by Charlemagne into Germany, was a corruption of that prevailing in the lower Greek empire, from which, together with the Arabian and German style, sprang the true German or Gothic architecture, which flourished from the thirteenth to the sixteenth century. The *basso-relievos* which are found on the oldest churches in Germany, and some pictures in them, still show the traces of the lower Grecian art. There are also to be found in Gori (see *Diptych*, vol. 3, p. 33 and 270, tab. iv. and xxiii.) and Ciampini (*Vet. Moniment.*, part ii. p. 104, tab. xxix.), representations of Italian and Gallic sculpture, which, in their drapery, ornaments and architectural forms, betray a Byzantine origin.

In regard to painting, we are indebted to the Byzantines for the preservation of some portion of its ancient excellence. As, in the early period of Christianity, Grecian and Roman art, in general, differed but little, since both sprung from the ruins of ancient art, so, in painting, no striking difference is to be observed between them. They became, however, constantly more and more distinct, in later times, as Greece and Italy became more and more separated. Short, thick bodies, stiff and forced attitudes, exaggeration of the characteristic parts, in particular of the eyes, faces contracted above and broad below, and marked with overcharged tints, short thick hair, highly-arched eyebrows, awkward drapery, loaded with unnatural folds, distinguish the Greek pictures as far back as the fifth century. The better paintings, which are found particularly in manuscripts, show a neat, accurate, and diligent execution. When art declined in Italy, particularly in the ninth century, painting was still cultivated by the Greeks, who, driven from home by the disputes concerning images, carried it into Italy and other countries, and adorned the churches there. Thus the lower Greek or Byzantine school was the mother of the old Italian school, and of the lower Rhenish, which preceded the German. The relation of both is seen in the similarity of the Italian pictures to those of the lower Rhenish school. According to the common statement, several Grecian artists passed over into Italy, in the beginning of the 12th century, and adorned the churches of Florence and Venice with their works. These were joined by the Italian artists, who founded, in the thirteenth century, a school of art and painting (see ITALIAN ART), which in its developement acquired a peculiar character, distinguished by beauty both of conception and execution. The lower Rhenish school, however, which is also called the *school of Cologne*, as it flourished chiefly, from the beginning of the fourteenth to the beginning of the fifteenth centuries, in the city of Cologne, appears to have retained still more closely the Byzantine character than the Italian did, since there are traces of it even in the later German school, exhibited in the symmetrical and pyramidal grouping of the objects, in the close drapery, and in the love of ornament and splendour, shown particularly in the golden back-grounds. The collection of the brothers Boisserée contains the most excellent works of this school. John Van Eyck first set the example of a more individual representation of natural objects, in opposition to the general representations of the lower Greek, and the ideal style of the old Roman school. More exact accounts are wanting of the historical connection of the lower Rhenish and of the old Italian school with the Byzantine style of art. (For an history of the earlier times of the Byzantine school of art, see *Histoire de l'Art par les Monumens depuis sa Décadence au 14me Siecle, jusqu'à son Renouvellement au 16me;* Paris, 1810, folio.)

CABIN; an apartment in a ship for officers and passengers. In large ships there are several cabins, the principal of which is occupied by the commander. In small vessels, there is only one cabin, which is in the stern. The bed-places in ships are also called *cabins*, or, more commonly, *berths*. *Berth* is used, likewise, for the room where a number of men mess and reside.

CABINET; 1. a small apartment adjoining a larger one; 2. the most retired part of a private dwelling, designed for work, for amusement, or for collections of valuable articles. 3. In the abode of a prince, the cabinet is a room set apart for the ruler's particular use; also, the apartment where he transacts government business, advises with his privy counsellors, and issues his decrees. Hence, in political language, the cabinet is put for the government; as the cabinet of London, of Vienna, of the Tuileries, &c. 4. Finally, a cabinet is any part of a building, or one or more whole buildings, where are preserved valuable col-

lections from the kingdoms of nature or art; as paintings, plants, animals, coins, minerals, and curiosities of every description; and, by metonymy, the name is applied to the collections themselves. A work of art, and sometimes of nature, of uncommon beauty, and fitted from its size to be placed in a cabinet, is called a *cabinet-piece*. A *cabinet-painter* is one who executes small highly-finished pictures, suitable for cabinets.

Cable; 1. in architecture, wreathed circular mouldings, resembling a robe; also, the staff which is left in the lower part of the flutings of some examples of the Corinthian and Composite orders.—2. In naval affairs, it is a long, thick rope, formed of 3 strands of hemp, which is employed for confining a vessel to its place by means of an anchor or other fixed body. The long and heavy chains which have been recently introduced for this purpose, are also called *cables*. Large vessels have ready for service 3 cables—the *sheet* cable, the *best bower* cable, and the *small bower* cable. They should be at least 100 or 120 fathoms in length. A best bower cable, of 25 inches in circumference, is formed of 3240 threads. The invention of iron cables is of recent date, and they have supplanted those of hemp in ships of war. They are stronger, less liable to be destroyed on rocks, &c. It is sometimes desirable to cut the cable when of hemp: this contingency is provided for in iron cables by a bolt and shackle at short distances, so that, by striking out the bolt, the cable is easily detached.—*Cable's length* is used to signify the measure of 120 fathoms, the usual length of a cable.

Caboose; the cook-room or kitchen of a ship. In smaller vessels, it is an enclosed fireplace, hearth, or stove, for cooking, on the main deck. In a ship of war, the cook-room is called a *galley*.—Caboose also signifies the box that covers the chimney in a ship.

Cacao. Chocolate is a kind of cake, or hard paste, the basis of which is the pulp of the cacao, or chocolate-nut, a production of the West Indies and South America. The cacao-tree (*theobromo cacao*), both in size and shape, somewhat resembles a young cherry-tree, but separates, near the ground, into four or five stems. The leaves are about four inches in length, smooth, but not glossy, and of a dull green colour. The flowers are saffron-coloured, and very beautiful. The fruit of the cacao-tree somewhat resembles a cucumber in shape, but is furrowed deeper on the sides. Its colour, while growing, is green; but, as it ripens, this changes to a fine bluish-red, almost purple, with pink veins; or, in some of the varieties, to a delicate yellow or lemon colour. Each of the pods contains from 20 to 30 nuts or kernels, which, in shape, are not much unlike almonds, and consist of a white and sweet pulpy substance, enveloped in a parchment-like shell. These are the cacao or chocolate-nuts.—Plantations of cacao are numerous on the banks of the river Magdalena, in South America. They are usually formed in morassy situations, and are sheltered from the intense heat of the sun by larger trees, which are planted in them. There are two principal crops of cacao in the year; the first in June, and the second in December. As soon as the fruit is ripe, it is gathered, and cut into slices; and the nuts which are at this time, in a pulpy state, are taken out, and laid in skins, or on leaves to be dried. They have now a sweetish acid taste, and may be eaten like any other fruit. When perfectly dry, they are put into bags, each containing about a hundred weight, and, thus packed, are exported to foreign countries. Previously to being formed into chocolate, these nuts are generally toasted or parched over the fire in an iron vessel, after which process their thin external covering is easily separated. The kernel is then pounded in amortar, and subsequently ground on a smooth, warm stone. Sometimes a little arnatto is added; and, with the aid of water, the whole is formed into a paste. This is put, whilst hot, into tin moulds, where in a short time it congeals; and in this state it is the chocolate of the shops. In South America and Spain, other modes are adopted: the chocolate is mixed with sugar, long pepper, vanilla, cinnamon, cloves, almonds, and other ingredients, according to the taste of the respective inhabitants. Mr. Edwards was of opinion, that the cakes of chocolate consumed in England were made of about one half cacao, and the remainder of flour or castile soap. That from Caraccas is considered the best.—By the natives of South America, the chocolate nuts are used for food. A white, oily matter, about the consistence of suet, is also obtained by bruising them, and boiling the pulp. The oil is by this means liquified, and rises to the surface, where it is left to cool and congeal, that it may the more easily be separated. This, which is called *butter of cacao*, is without smell, and when fresh, has a very mild taste. Its principal use is as an ingredient in pomatums. From the nuts, when slightly roasted, an oil is sometimes obtained by pressure, which is occasionally used in medicine.

Cadence, or Reprise; a pause or suspension at the end of an air, to afford the performer an opportunity of introducing a graceful extempore close. The word *cadence* is also frequently applied to the embellishment itself.

Cæsarian Operation. See Midwifery.

Cahors Wine is that wine which is used to improve the Pontac and other red French wines. It is consumed in Bourdeaux and other places, where the lighter and cheaper French wines find a ready market.

Caisson; 1. a chest filled with combustibles, and buried under ground, in order to explode at a particular time. It is also a covered waggon for the provisions and ammunition of an army.—2. In architecture, a kind of chest, case, or flat-bottomed boat, used in the construction of bridges, large enough to contain an entire pier, which is built in it; the caisson is then sunk to the bed of the river, and the sides removed from the bottom, which is left as a foundation for the pier.—Floating vessels, under the same name, are used to close the entrances of docks and basins. A groove is worked in the masonry of the entrance, and a vessel of the shape of the opening, with a projection corresponding to the groove, a hanging scuttle on each side, and furnished with pumps, is floated into it at high tide. The scuttles being opened, the caisson sinks, and fills up the groove. The scuttles are then shut, and the water is prevented from entering the dock, or from discharging itself from the basin. If the dock is to be filled, the scuttles are opened, till the water is nearly on a level on each side, when the scuttles are again shut, the caisson emptied by the pumps, and then floated off.

Cajeput Oil; the volatile oil obtained from the leaves of the cajeput-tree—the *cajeputa officinarum* (the *melaleuca leucadendron* of Linnæus). The tree which furnishes the cajeput oil is common on the mountains of Amboyna, and the other Molucca is-

lands. It is obtained by distillation from the dried leaves of the smaller of two varieties. It is prepared in great quantities in the island of Banda, and sent to Holland in copper flasks. As it comes to us, it is of a green colour, very limpid, lighter than water, of a strong smell resembling camphor, and of a strong, pungent taste. It burns entirely away, without leaving any residuum. It is often adulterated with other essential oils, coloured with the resin of milfoil. In the genuine oil, the green colour depends on the presence of copper; for when rectified it is colourless.

CALAMANCO; a woollen stuff, principally manufactured in the Netherlands. The English manufactures of it have declined of late years. The warp is sometimes mixed with silk or goats' hair. This stuff is made plain, coloured, striped, or watered.

CALAMATA. See GREECE.

CALAMINE. See ZINC.

CALCARIOUS SPA; a combination of lime and carbonic acid. See LIME.

CALCINATION. Calcination, as commonly understood, consists in heating bodies in a steady fire, at a greater or less temperature. The product is a powder which is called *calx*. In a narrow sense, we understand by this process a change of metals into a metallic calx, or metallic earth. Metals are calcined in two ways—by the dry method, which consists in burning them in the open air, or by the wet method, which consists in dissolving the metal and precipitating its calx. Take, for instance, a quantity of lead, and melt it in the open air in a flat vessel; it soon assumes a grayish hue, the earthy substance forming a coat on the surface. Upon the removal of this, the metal appears having a brilliant lustre, and after some time, the same gray coat reappears. It may be removed as long as any lead remains. This substance is the calx. Calcined lead is specifically lighter than the metal, but its absolute weight is considered greater, so that 10 pounds of metal makes 11 pounds of calx. Platina, gold, and silver are not affected in this way in so great a degree, on which account they are called the *perfect metals*. Chemists are now convinced, that in this process the atmospheric air is decomposed, and a portion absorbed by the metal, which accounts for its increase of weight. Calcination is, therefore, nothing but oxydation; and, as the body is not saturated with oxygen, no acid is formed, but the result is a metallic oxide.

CALCOGRAPHY. See ENGRAVING.

CALCULUS, in *Mathematics;* the lower or common analysis. It contains the rules necessary to calculate quantities of any definite magnitude whatever. But quantities are sometimes considered as varying in magnitude, or as having arrived at a given state of magnitude by successive variations. This gives rise to the higher analysis, which is of the greatest use in the physico-mathematical sciences. Two objects are here proposed: First, to descend from quantities to their elements. The method of effecting this is called the *differential calculus*. Second, to ascend from the elements of quantities to the quantities themselves. This method is called the *integral calculus*. Both of these methods are included under the general name *infinitesimal analysis*. Those quantities which retain the same value are called *constant;* those whose values are varying are called *variable*. When variable quantities are so connected that the value of one of them is determined by the values ascribed to the others, that variable quantity is said to be a *function* of the others. A quantity is *infinitely great* or *infinitely small*, with regard to another, when it is not possible to assign any quantity sufficiently large or sufficiently small to express the ratio of the two. When we consider a variable quantity as increasing by infinitely small degrees, if we wish to know the value of those increments, the most natural mode is to determine the value of this quantity for any one instant, and the value of the same for the instant immediately following. This difference is called the *differential* of the quantity. The *integral calculus*, as has been already stated, is the reverse of the *differential calculus*. There is no variable quantity expressed algebraically, of which we cannot find the differential; but there are differential quantities, which we cannot integrate: some, because they could not have resulted from *differentiation;* others, because means have not yet been discovered of integrating them.

We have made these elementary observations for the purpose of introducing the history of the discovery of this mighty instrument. For a full examination of the subject, we refer to Lacroix's works, Carnot's *Métaphysique du Calcul Infinitesimal*, Lagrange's *Calcul des Fonctions*. Newton was the first discoverer, having pointed out the principles in a treatise written before 1669, but not published till many years after. Leibnitz, meanwhile, made the same discovery, and published it to the world before Newton, and independently of Newton's prior discoveries, with a much better notation, which is now universally adopted. The methods analogous to the infinitesimal analysis previously employed were that of *exhaustions*, known to the ancients, that of *indivisibles* of Cavalieri, and Descartes' method of *indeterminates*. Leibnitz considered the differences of the variable quantities as infinitely small, and conceived that he might reject the higher powers of those differences without sensible error; so that none of those powers but the first remained in the differential equation finally obtained. Instead of the actual increments of the *flowing* or variable quantities, Newton introduced the *fluxions* of those quantities; meaning, by fluxions, quantities which had to one another the same ratio which the increments had in their ultimate or evanescent state. The *fluxions* of Newton corresponded with the *differentials* of Leibnitz; and the *fluents* of the former with the *integrals* of the latter. The fluxionary and the differential calculus are therefore two modifications of one general method.

The problems which relate to the *maxima* and *minima*, or the greatest and least values of variable quantities, are among the most interesting in mathematics. When any function becomes either the greatest or the least, it does so by the velocity of its increase or decrease becoming equal to nothing: in this case, the fluxion which is proportional to that velocity must become nothing. By taking the fluxion of the given function, and supposing it equal to nothing, an equation may be obtained in finite terms, expressing the relation of the quantities when the function assigned is the greatest or least possible. The new analysis is peculiarly adapted to physical researches. The momentary increments represent precisely the forces by which the changes in nature are produced: so that this doctrine seemed created to penetrate into the interior of things, and take cognizance of those powers which elude the ordinary

methods of geometrical investigation. It alone affords the means of measuring forces, when each acts separately and instantaneously, under conditions that can be accurately ascertained. In comparing the effects of continued action, the variety of time and circumstance, and the continuance of effects after their causes have ceased, introduce uncertainty, and render the conclusions vague and unsatisfactory. The analysis of infinites here goes to the point; it measures the intensity or instantaneous effort of the force, and removes all those causes of uncertainty. It is by effects, taken in their nascent or evanescent state, that the true proportion of causes must be ascertained.

Calculus. Little stones, anciently used for computation, voting, &c., were called *calculi*. The Thracians used to mark lucky days by white, and unlucky by black pebbles; and the Roman judges, at an early period, voted for the acquittal of the accused by a white, and for condemnation by a black calculus: hence, *niger* or *albus calculus*, a favourable or unfavourable vote. Sometimes the ballots were marked with characters, and then were made of wood. *Calculi lusorii* or *latrones* were counters used in a game, something like backgammon. *Calculus Minervæ* was an expression employed to signify that the accused escaped by an equal division of the votes of the judges. He was said to be acquitted *calculo Minervæ* (by the vote of Minerva), because Orestes was acquitted by the vote of that goddess when the judges were equally divided.

Calculus, or Stone, is the name given to all hard concretions, not bony, formed in the bodies of animals. Calculi may be divided into two classes, according as they are found in the gall-bladder or in the urinary bladder. The first are called *biliary calculi*, the second *urinary calculi*.

Biliary calculi are of a lamellated structure, and are composed of a substance which is considered by M. Chevreul as a peculiar principle, which he has named *cholesterine*. It is described as a white crystalline substance, with much lustre, insipid and inodorous, much resembling spermaceti, but differing in being less fusible, and in not forming a soap with alkalies. It is also converted, by the action of nitric acid, into a peculiar acid, called *cholesteric acid*. This is slightly soluble in water, and forms soluble salts with the alkalies. Cholesterine consists of carbon 85.095, oxygen 3.025, and hydrogen 11.88. It has lately been detected in the bile itself, both in that of animals and of man. Besides cholesterine, biliary concretions contain a portion of inspissated bile, and the yellow colouring matter of the bile in a concentrated state, which from the beauty and permanence of its hue, is much valued as a pigment.

Urinary calculi are of very variable characters and composition. The following substances enter principally into their composition: uric acid, urate of ammonia, phosphate of lime, phosphate of ammonia and magnesia, oxalate of lime, silex, sometimes oxide of iron and animal matter—these being more or less pure or mixed, and being often diversified by mechanical structure, so as to render it difficult to constitute well-defined species. The six following species embrace the principal varieties of urinary calculi: 1. that composed chiefly of uric acid; 2. that consisting chiefly of the triple phosphate of ammonia and magnesia; 3. the bone-earth calculus, formed almost entirely of phosphate of lime; 4. the fusible calculus, composed of the two preceding intermixed; 5. the mulberry calculus, consisting of oxalate of lime; and, 6. a rare species, the cystic oxide calculus. Two others, still more rare, are the xanthic oxide and fibrinous calculus, discovered by Doctor Marcet; and, lastly, calculi have been met with formed of carbonate of lime. In all these calculi, besides the saline matter, there is present a portion of animal matter, which is conceived to be the mucus of the bladder. This seems to give them colour and induration. It is found even in those which are white and crystalline. In the mulberry calculus it is present in a larger proportion than in the others. The ingredients of calculi are often, also, diversified by intermixture in layers. These must, of course, be various, and as their production is in some measure accidental, irregularly arranged. Those which have been the most frequently observed are alternations of uric acid with phosphate of magnesia and ammonia, or phosphate of lime; or of oxalate of lime with uric acid, or with either or both of these phosphates.

Calendar; the division of time into years, months, weeks, and days; also a register of these divisions. Among the old Romans, for want of such a register, it was the custom for the *pontifex maximus*, on the first day of the month, to proclaim (*calare*) the month with the festivals occurring in it, and the time of new moon. Hence *calendæ* and *calendar*. The periodical occurrence of certain natural phenomena gave rise to the first division of time. The apparent daily revolution of the starry heavens and the sun about the earth occasioned the division into days. But, as the number of days became too great for convenience, some larger measure of time was found necessary. The changes of the moon, which were observed to recur every 29 or 30 days, suggested the division of time into months. After a considerable period these also were found to multiply too much, and a still larger measure of time was wanted. Such a one was found in the apparent yearly revolution of the sun round the earth in the ecliptic. The time of this revolution, after several erroneous calculations hereafter to be mentioned, was finally determined to be a little more than 365 days. This was called a *solar year*, or simply a *year*, which was divided according to the former measures of time, into months and days. Now, on account of the great influence of the sun's course in the ecliptic, and its consequent variations of distance from us upon the earth, and the affairs of its inhabitants in all countries, the attention of men would naturally be drawn to this phenomenon. Hence it has happened that all nations, in any degree civilized, have adopted the year as the largest measure of time. It is probable that the Phœnicians first, then the Egyptians, and afterwards the Greeks, made use of this mode of reckoning, from whom it was communicated to other nations. The division of the year, however, into months and days, could not have been very accurate at first, because it can be settled only by long and attentive observation. The calendar of the oldest nations was quite imperfect. They were satisfied with one which enabled them to manage the common business of husbandry.

The Greeks were the first who attempted to adjust the courses of the sun and the moon to each other. For this purpose, they reckoned 12½ revolutions of the moon round the earth for one solar year; and, to avoid the fractions of a month, they made the year consist of 13 and 12 months alternately. Solon,

perceiving the defects of this arrangement, fixed the number of days in a month at 29½, and made the month consist of 29 and 30 days alternately. Still the length of the month and that of the year were not brought into exact adjustment, and new disorders soon followed. Various plans for the reformation of the calendar were proposed from time to time; but all proved insufficient, till Meton and Euctemon finally succeeded in bringing it to a much greater degree of accuracy, by fixing on the period of 19 years, in which time the new moons return upon the same days of the year as before (as 19 solar years are very nearly equal to 235 lunations). This mode of computation, first adopted by the Greeks (433 B. C.), was so much approved of, that it was engraven with golden letters on a tablet at Athens. Hence the number showing what year of the moon's cycle any given year is, is called the *golden number*. This period of 19 years was found, however, to be about six hours too long. This defect, Calippus, about 102 years later, endeavoured to remedy, but still failed to make the beginning of the seasons return on the same fixed day of the year. Among the Romans, their first king, Romulus, introduced a year of 10 divisions or months, of which four (March, May, July, and October) contained 31 days; the rest (April, June, August, September, November, and December), only 30. When he discovered that this mode of reckoning was imperfect, he inserted as many days as were necessary to complete the year, and bring it up to the beginning of the following one. His successor, Numa Pompilius, abolished this method, added 50 days more, took one day from each of the six months containing 30 days, because even numbers were considered unlucky, and out of the whole 26 days formed two new months of 28 days each, which he called *January* and *February*. Thus the year consisted of 12 months, and 350 days; and to make it agree with the course of the sun, intercalations were made use of, after the manner of the Greeks. These intercalations, however, were left to the discretion of the priests; and, as they made them very arbitrarily, according to the exigencies of the state, or their own private views, complaints and irregularities soon arose. Notwithstanding this defect, the arrangement continued to the end of the republican constitution.

The calendar of the Romans had a very peculiar arrangement. They gave particular names to three days of the month. The first day was called the *calends*. In the four months of March, May, July, and October, the 7th, in the others, the 5th day, was called the *nones*; and, in the four former, the 15th, in the rest, the 13th day, was called the *ides*. The other days they distinguished in the following manner: they counted from the above-mentioned days backwards, observing to reckon also the one from which they began. Thus the 3d of March, according to the Roman reckoning, would be the 5th day before the *nones*, which in that month fall upon the 7th. The 8th of January, in which month the *nones* happen on the 5th, and the *ides* on the 13th, was called the 6th before the *ides* of January. Finally, to express any of the days after the *ides*, they reckoned in a similar manner from the calends of the following month. From the inaccuracy of the Roman method of reckoning, it appears that, in Cicero's time, the calendar brought the vernal equinox almost two months later than it ought to be. According to the last letter of the 10th book of *Cicero's Letters to Atticus*, this equinox was not yet past, although it was near the end of May, by their calendar. To check this irregularity, Julius Cæsar, on being appointed dictator and pontiff (A. U. C. 707), invited the Greek astronomer Sosigenes to Rome, who, with the assistance of Marcus Fabius, invented that mode of reckoning, which after him who introduced it into use, has been called the *Julian calendar*. The chief improvement consisted in restoring the equinox to its proper place in March. For this purpose, two months were inserted between November and December, so that the year 707, called, from this circumstance, the *year of confusion*, contained 14 months. In the number of days, the Greek computation was adopted, which made it 365¼.

The number and names of the months were kept unaltered, with the exception of Quintilis, which was henceforth called, in honour of the author of the improvement, *Julius*. To dispose of the quarter of a day, it was determined to intercalate a day every fourth year, between the 23d and 24th of February. This was called an *intercalary* day, and the year in which it took place was called an *intercalary* year, or as we term it, a *leap* year. This calendar continued in use among the Romans until the fall of the empire, and throughout Christendom till 1582. The festivals of the Christian church were determined by it. With regard to Easter, however, it was necessary to have reference to the course of the moon. The Jews celebrated Easter (the Passover) on the 14th of the month Nisan (or March); the Christians in the same month, but always on a Sunday. Now, as the Easter of the Christians sometimes coincided with the Passover of the Jews, and it was thought unchristian to celebrate so important a festival at the same time as the Jews did, it was resolved at the Council of Nice, 325 A.D., that from that time Easter should be solemnized on the Sunday following the first full-moon after the vernal equinox, which was then supposed to take place on the 21st of March. As the course of the moon was thus made the foundation for determining the time of Easter, the lunar cycle of Meton was taken for this purpose; according to which the year contains 365¼ days, and the new moons, after a period of 19 years, return on the same days as before. The inaccuracy of the Julian year, thus combined with the lunar cycle, must have soon discovered itself, on a comparison with the true time of the commencement of the equinoxes, since the received length of 365¼ days exceeds the true by about 11 minutes; so that for every such Julian year, the equinox receded 11 minutes, or a day in about 130 years. In consequence of this, in the 16th century, the vernal equinox had changed its place in the calendar from the 21st to the 10th; that is, it really took place on the 10th instead of the 21st, on which it was placed in the calendar.

Aloysius Lilius, a physician of Verona, projected a plan for amending the calendar, which, after his death, was presented by his brother to Pope Gregory XIII. To carry it into execution, the pope assembled a number of prelates and learned men. In 1577, the proposed change was adopted by all the Catholic princes; and in 1582, Gregory issued a brief abolishing the Julian calendar in all Catholic countries, and introducing in its stead the one now in use, under the name of the *Gregorian* or *reformed calendar*, or the *new style*, as the other was now called the *old style*. The amendment consisted in this:—10 days

were dropped after the 4th of October, 1582, and the 15th was reckoned immediately after the 4th. Every 100th year, which, by the old style was to have been a leap year, was now to be a common year, the 4th excepted; i.e., 1600 was to remain a leap year, but 1700, 1800, 1900, to be of the common length, and 2000 a leap year again. In this calendar the length of the solar year was taken to be 365 days, 5 hours, 49 minutes, and 12 seconds. Later observations of Zach, Lalande, and Delambre, fix the average length of the tropical year at about 27 seconds less; but it is unnecessary to direct the attention of the reader to the error arising from this difference, as it will amount to a day only in the space of 3000 years.

Notwithstanding the above improvement, the Protestants retained the Julian calendar till 1700, when they also adopted the new style, with this difference, that they assigned the feast of Easter to the day of the first full moon after the *astronomical* equinox. But this arrangement produced new variations. In 1724 and 1744, the Easter of the Catholics was eight days later than that of the Protestants. On this account, the Gregorian calendar was finally adopted, 1777, in Germany, under the name of the *general calendar of the empire*, or as it is now called, the *reformed calendar*, in order that the Catholics and Protestants might celebrate Easter, and, consequently, all the moveable feasts at the same time. England introduced the new style in 1752, and Sweden in 1753. Russia only retains the old style, which now differs 12 days from the new.

In France, during the revolution, a new calendar was introduced, by a decree of the National Convention, Nov. 24, 1793. The time from which the new reckoning was to commence was the autumnal equinox of 1792, which fell upon the 22d of Sept., at 18 minutes and 30 seconds after 9 A. M., Paris time. This day was selected as that on which the first decree of the new republic had been promulgated. The year was made to consist of 12 months of 30 days each, and, to complete the full number of days, 5 *jours complementaires* were added to the end of it, in common years, and 6 in leap years. Each period of 4 years, terminating with a leap year, was called a *franciade*. Instead of weeks, each month was divided into 3 parts, called *decades*, consisting of 10 days each; the other divisions being also accommodated to the decimal system. The names of the months were so chosen as to indicate by their etymology, the time of year to which they belonged. They were as follows:—Autumn, from the 22d Sept. to the 22d Dec.; *Vendémiaire*, vintage month (Oct.); *Brumaire*, foggy month (Nov.); *Frimaire*, sleet month (Dec.):—Winter, from 22d Dec. to 22d March; *Nivôse*, snowy month (Jan.); *Ventôse*, windy month (Feb.) *Pluviôse*, rainy month (March):—Spring from 22d March to 22d June; *Germinal*, bud month (April); *Floréal*, flower month (May); *Prairial*, meadow month (June):—Summer, from 22d June to 22d Sept.; *Messidor*, harvest month (July); *Thermidor*, hot month (Aug.); *Fructidor*, fruit month (Sept.). The 10 days of each decade were called, 1. *Primidi*, 2. *Duodi*, 3. *Tridi*, 4. *Quartidi*, 5. *Quintidi*, 6. *Sextidi*, 7. *Septidi*, 8. *Octidi*, 9. *Nonidi*, 10. *Decadi* (the Sabbath). Besides this, each day in the year had its particular name, appropriate to the time when it occurred; as, the 7th of Vintage month, *Vendémiaire*, was named *carottes* (carrots). This calendar was abolished, at the command of Napoleon, by a decree of the senate, 9th Sept., 1805, and the common Christian or Gregorian calendar introduced throughout the French empire.

CALENDER. Different fabrics, before they leave the hands of the manufacturer, are subjected to certain processes, the object of which is to make them smooth and glossy, to glaze them, to water them, or give them a wavy appearance. This is done, in general, by pressing the fabric between wooden or metallic cylinders, whence the machine is called a *calender*, and the workman a *calender* or *calenderer*.

CALENDS, with the Romans, the first days of the month; so called because the *pontifex maximus* then proclaimed (*calavit*) whether the *nones* would be on the 5th or the 7th. This was the custom until the year 450 U.C., when the *fasti calendares*, or calendar were affixed to the wall of public places. The Greeks did not make use of calends; whence the proverbial expression *ad Græcas calendas* (on the Greek calends), meaning *never*. The calends of January were more solemn than the others, and were consecrated to Janus and Juno. On this day the magistrates entered on their offices, and friends interchanged presents. On the calends, debtors were obliged to pay the interest of their debts; hence *tristes calendæ*. The book of accounts was called *Calendarium*.

CALENTURE; a violent fever, incident to persons in hot climates, especially to such as are natives of cooler climates. It is attended with delirium; and the patient imagines the sea to be a green field, in which he is tempted to walk by the coolness and freshness of its appearance. This is, at least, the poetical explanation of the matter. The fact seems to be, that the intense inflammation of the fever prompts the patient to plunge into cold water to relieve his sufferings.

CALIBER; the interior diameter of the bore of any piece of ordnance, or the diameter of a shot or shell.

Caliber or *caliper compasses* are a sort of compasses with arched legs, used in the artillery practice, to take the diameter of any round body, particularly of shot or shells, the bore of ordnance, &c. The instrument consists of two thin pieces of brass, joined by a rivet, so as to move quite round each other. It contains a number of tables, rules, &c., connected with the artillery practice.

CALICO; a cotton cloth, which derives its name from Calicut, a city of India, from which it was first brought. In England, white or unprinted cotton cloth is called *calico*. Calico printing is a combination of the arts of engraving and dyeing, and is used to produce upon woven fabrics, chiefly of cotton, a variety of ornamental combinations, both of figure and colour. In this process, the whole fabric is immersed in the dyeing liquid; but it is previously prepared in such a manner, that the dye adheres only to the parts intended for the figure, while it leaves the remaining parts unaltered. In calico-printing adjective colours are most frequently employed. The cloth is prepared by bleaching, and other processes, which dispose it to receive the colour. It is then printed with the mordant, in a manner similar to that of copperplate-printing, except that the figure is engraved upon a cylinder instead of a plate. The cylinder, in one part of its revolution, becomes charged with the mordant mixed to a proper consistence with starch. The superfluous part of the mordant is then scraped off by a straight steel edge, in con-

tact with which the cylinder revolves, leaving only that part which remains in the lines of the figure. The cloth then passes in forcible contact with the other side of the cylinder, and receives from it a complete impression of the figure in the pale colour of the mordant. The cloth is then passed through the colouring bath in which the parts previously printed become dyed with the intended colour. When it is afterwards exposed and washed, the colour dis appears from those parts which are not impregnated with the mordant, but remains permanently fixed to the rest. When additional colours are required, they are printed over the rest, with different mordants, suited to the colour intended to be produced. This secondary printing is generally performed with blocks, engraved in the manner of wood-cuts, and applied by hand to the successive parts of the piece. See WEAVING.

CALK; to drive a quantity of oakum into the seams of planks, to prevent the entrance of the water. After the oakum is driven in, it is covered with melted pitch or resin, to preserve it from the action of the water.

CALLUS is a preternatural hardness, whether carneous or osseous. The new growth of bony substance between the extremities of fractured bones, by which they are united, is an instance of the latter. External friction or pressure produces the former, as in the hands of labourers, and the feet of persons who wear tight shoes.

CALMS, REGION OF. In the Atlantic Ocean, between the tropic of Cancer and lat. 29° N., and on the confines of the trade-winds, between 4° and 10° N. lat., calms of long duration prevail; and hence these tracts are called the *calm latitudes*, or the *regions of calms*. In the latter tract particularly, these perpetual calms are accompanied by a suffocating heat, by thunder-storms, and floods of rain, so that it is sometimes called the *rainy sea*. The only winds that occur are sudden squalls of short duration and little extent. In these calms the provisions are corrupted, the seams open, and the stagnant air breeds disease. When a ship is in this positon, if the currents set in towards rocks, and the sea is too deep to cast anchor, her destruction is almost inevitable. In the Mediterranean, where there are no tides, *dead calms* are more common than in the open ocean; but they are often the presages of approaching storms.

CALOMEL, or mild muriate of mercury, is a very important article in the *pharmacopœia*. The preparation may be thus described: If four parts of corrosive muriate of mercury be well mingled by trituration with three of mercury, they assume the form of a gray powder. If this powder be sublimed in a sand heat, either from an ordinary phial, or from a bolthead, a white crystalline sublimate is obtained. This product is a combination of oxide of mercury with muriatic acid. It is much used in medicine, especially for biliary diseases.

CALORIC is the name given in chemistry to that agent which produces the phenomena of heat and combustion. It is hypothetically regarded as a subtile fluid, the particles of which repel one another, and are attracted by all other substances. It is imponderable, and, by its distribution in various proportions among the particles of matter, gives rise to the three general forms of gas, liquids, and solids. The particles of water, by losing caloric, have their cohesion so much increased, that they assume the solid form of ice; by adding caloric, they again become fluid; and by a still farther addition, they are converted into vapour.

Caloric exists in two different states—*free* or *uncombined*, and *in a state of combination*. In the former condition, it creates the sensation of heat, and produces expansion in other bodies. The power which any body has of exciting the sensation of heat, and occasioning expansion, is understood by the expression of its *temperature*. This is supposed to vary with the quantity of free caloric in a given quantity of matter; a high temperature being ascribed to the presence of a large quantity of free caloric, and a low temperature to that of a small quantity. We are ignorant, however, of the extremes of temperature, and may compare it to a chain, of which a few of the middle links only, are exposed to our observation, while its extremities are concealed from our view.

The *expansion of bodies* is one of the most universal effects of an increase of temperature. This increase in bulk, however, is not the same in all bodies. The same increase of temperature causes liquids to expand more than solids, and aëriform bodies much more than either. On this principle are constructthe various instruments for measuring the temperature; since the degree of expansion produced by caloric bears a sufficient proportion to its quantity to afford us the means of ascertaining it with tolerable accuracy. Our senses, it is obvious, are quite inadequate to afford us this information; for we compare our sensations of heat, not with any fixed or uniform standard, but with those sensations which we have had immediately previous. Hence, the same portion of water will feel warm to a hand removed from contact with snow, and cold to another hand which has been heated before the fire. To convey precise notions of temperature, therefore, we are obliged to describe the degree of expansion produced in some one body which has been previously agreed upon as a standard of comparison. The standard most generally adopted is quicksilver, which is contained in a glass ball, terminating in a long narrow tube. This instrument is called a *thermometer*.

If quicksilver, or, indeed, any other substance except the gases, suffered equal exapansion by equal increments of the calorific power, then this instrument would be perfect; but the same increase of bulk is not effected in the same liquid or solid, at all temperatures, by adding similar quantities of heat; for bodies expand, by equal increments of caloric, more in high than in low temperatures, because the force opposing expansion is diminished by the interposition of caloric between the particles of bodies; and, therefore, when equal quantities of caloric are added in succession, the last portions meet with less resistance to their expansive force than the first. In gases, on the contrary, which are destitute of cohesion, equal increments of heat appear to be attended with equal augmentations of bulk. The *tendency to an equilibrium* is a characteristic of free caloric.

Any number of different bodies, unequally heated, when exposed in an apartment to the same temperature, gradually arrive to an equality of temperature. It is in obedience to this law, that we experience the sensations of heat and cold when we touch bodies which are warmer or colder than ourselves. There exists much diversity in the rapidity with which

different substances attract caloric when in contact with a body in which it is accumulated. Common air and gases abstract it but tardily, while wood, stones, and metals acquire it more rapidly. According to their power of conducting it off under these circumstances, bodies are divided into *conductors* and *non-conductors* of caloric; and, in general, the power of conduction varies with the densities of bodies. But this tendency of caloric to an equilibrium is not established solely by the agency of intermediate bodies or communication. A part of it moves through the atmosphere, like light, in right lines, and with immeasurable velocity, and has therefore been called *radiant caloric*. The comparative quantites lost by radiation and by conduetion may be approximated by observing what time it takes to cool any body through the same number of degrees in air and *in vacuo*. Thus Doctor Franklin imagined he had ascertained that a body which requires five minutes to cool *in vacuo*, will cool in air, through the same number of degrees, in two minutes. Count Rumford's experiments, with a Torricellian vacuum, give the proportions of five to three.

Radiant caloric passes only through transparent media, or free space. When, in its passage, its rays impinge upon the surface of a solid or a liquid substance, they are either reflected from it, and thus receive a new direction, or they lose their radiant form altogether, and are absorbed. In the latter case, the temperature of the receiving substance is increased; in the former it is unchanged. The nature of the surface of a body has been found to influence powerfully both the radiation and absorption of caloric. The energy of calorific emanation from a cubical tin vessel, coated with different substances, and containing warm water (as determined by the differential thermometer of Leslie), gave, with a covering of

Lampblack, ...	100
Isinglass, ...	75
Tarnished lead, ...	45
Polished iron, ...	15
Tin-plate, gold, silver, or copper,	12

Similar results were obtained simply by noting the rates of cooling in vessels of similar shapes and capacities with various surfaces. Useful lessons have been derived from these discoveries. Tea and coffee-pots, which are intended to retain their heat, are made of bright and polished metals; and steam-pipes, intended to convey heat to distant apartments, are kept bright in their course, but darkened where they reach their destination. The power of different surfaces to absorb caloric was found, by coating one of the bulbs of the differential thermometer successively with different substances, and presenting it to an uniformly heated substance, to follow the same order as the radiating or projecting quality.

With regard to *combined caloric*, it has been shown that solids, during liquefaction, imbibe a quantity of caloric, which ceases to be obvious, both to our senses and to the thermometer. The same is also true of solids and liquids in their conversion into vapours or gases; a portion of caloric, which is essential to the elasticity of the new product, ceases to become apparent. Whenever this effect takes place, *cold* is said to be produced; by which we are only to understand the passage of caloric from a free to a latent form. The reverse of these phenomena has also been satisfactorily established; viz. when the density of bodies is increased, either by chemical or mechanical means, caloric is evolved. For example, a high temperature is produced by mingling cold sulphuric acid and water; metals become intensely heated by the augmentation of their density through hammering; liquids, by becoming solids, or gases by conversion into liquids also evolve caloric. A pound of water, condensed from steam, will render 100 pounds of water at 50° warmer by 11°; whereas, a pound of boiling water will produce the same rise of temperature in no more than about 13.12 pounds; and since steam and boiling water affect the thermometer in the same manner, this effect can be produced only from the existence of a much greater quantity of caloric in the former than in the latter.

The *sources of caloric* are six; viz. the sun's rays, combustion, percussion, friction, the mixture of different substances, electricity, and magnetism.

CALORIMETER; an instrument to measure the capacity of a body for caloric, or its specific caloric. The thermometer measures merely the variations of temperature, or sensible heat. The body in the calorimeter is placed in the innermost of three concentric vessels, the two outer ones containing ice; the quantity of water produced by the cooling of the body a given number of degrees, determines its specific caloric. This instrument was invented by Lavoisier and Laplace. In the calorimeter invented by Rumford, water is used; the capacity of the body is determined by the number of degrees which the temperature of the water is raised, in cooling the body a given number of degrees.

CALORIMOTOR. See GALVANIC BATTERY.

CALX; properly lime or chalk; but the term is more generally applied to the *residuum* of a metal or mineral which has been subjected to violent heat, burning or calcination, solution by acids, or detonation by nitre, and which is or may be reduced to a fine powder. Metallic calces are now called *oxides*. They weigh more than the metal from which they are produced, on account of the oxygen which they have obsorbed.

CAMAIEU. This term is used for a painting wherein there is only one colour, and where the lights and shades are of gold, wrought on a golden or azure ground. When the ground is yellow, the French call it *cirage*, when gray, *grissaile*. This kind of work is chiefly used to represent *basso-relievos*. See CAMEO.

CAMBLET, in *Commerce*; a stuff sometimes of wool, sometimes of silk, and sometimes hair, especially that of goats, with wool or silk; in some, the warp is silk and wool twisted together, and the woof hair.

The true, or Oriental camblet, is made of the pure hair of a sort of goat frequent about Angora, and which makes the riches of that city, all the inhabitants being employed in the manufacture and commerce of camblets.

CAMBRIC, in *Commerce*; a species of linen made of flax, very fine and white; the name of which was originally derived from the city of Cambray, where they were first manufactured.

CAMEL, in *Mechanics*; a machine used in Holland and St. Petersburg for lifting ships over shallow bars. De Witt invented these machines, and Peter the Great introduced them into Russia. A camel is composed of two separate parts, the insides of which

are shaped so as to embrace the hull of a ship on both sides. Each part has a cabin, with many pumps and plugs. They are fastened to the vessel underneath, and entirely enclose its sides and bottom. They are then towed to the bar, and are sunk with the vessel, by taking out the plugs. The water being now pumped out, the camel lifts the vessel, and the whole is towed over the bar.

Camelopardalus, in *Astronomy*; a new constellation of the northern hemisphere, described by Hevelius, consisting of 32 stars, first observed by him, situate between Cepheous, Cassiopea, Perseus, the two Bears, and Draco, and containing 58 stars in the British Catalogue.

Cameo, or Camaieu; in the proper sense, a gem engraved in *relievo*. The ancients generally used the onyx for this purpose. At first, such onyxes, and afterwards all gems carved in relief, were called *cameos*. They were carved according to the layers of the stone, so that the ground should be of a different colour from the figure in relief. One of the most famous cameos is the onyx at present in Paris, called the *Apotheosis of Augustus*, 1 foot high and 10 inches wide.

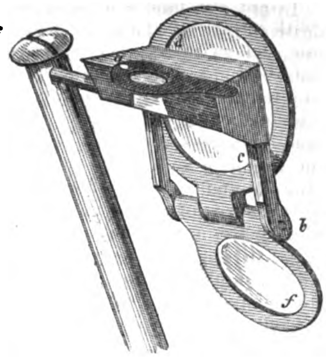
Camera Lucida. This optical instrument, in the hands of an experienced draftsman, is admirably fitted to save time, and supply the place of a knowledge of perspective. Generally speaking, however, the *camera lucida* is laid aside as soon as it is taken in hand, as much practice is essential to its useful application.

If a piece of plain glass be fixed at an angle of 45 degrees with the horizon, and if, at some distance beneath there be a sheet of paper laid horizontally on a table, a person looking downwards through the glass, will see an image of the objects situated before him; and as the glass which reflects the image is also transparent, the paper and pencil will be seen at the same time with the image, so that the outline of the image may be traced on the paper. The image is an *inverted* one. This is the simplest form of the instrument, and may be constructed extemporaneously by fixing on a stand a plain transparent glass, with its surfaces ground parallel, or a piece of Muscovy glass, at an angle of 45 degrees with the horizon; a card, with a small hole in it, will serve as a sight for keeping the eye steady in one situation, whilst the pencil is tracing the image.

If there be a plain object at an angle of 22½ degrees with the horizon, and a piece of plain transparent glass be placed near it, at an angle of 22½ degrees with the vertical, the rays from the object will be twice reflected before they reach the eye, and consequently on looking down through the transparent glass, an *erect* image is seen, and the pencil may be drawn over the outlines of this image so as to leave a perspective representation on the paper.

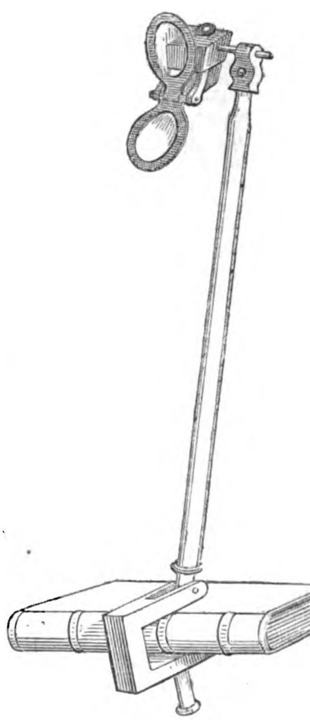
As the image and pencil are at different distances, they cannot be both seen in the same state of the eye. To remedy this inconvenience, a convex glass is used, of such focus as to require no more effort than is necessary for seeing the distant objects distinctly. By means of this lens, the image will appear as if it were placed on the surface of the paper.

Those whose eyes are adapted to seeing near objects alone, will not derive advantage from the use of a convex glass, but will require a concave glass to be placed in the course of the rays from the object to the reflecting surface.



In the accompanying figure *d f* are glasses placed in the above-mentioned situation; they are so disposed as to be turned at pleasure into their proper place at the joint *b*. Persons whose sight is nearly perfect, may use either the concave glass placed before the reflecting surface, or the convex glass placed between the paper and the eye.

In the actual construction of the instrument, a prism is used instead of a mirror and a plain glass. The rays from the object fall upon the surface of the prism. This surface is inclined 22½ degrees to the horizon. The refractive power of the glass allow snone of the rays in this position to pass out; they are all reflected. The eye cannot see the pencil through the prism as it does through a plain glass; therefore, in order that the pencil may be seen, the eye must be so placed that only a part of the pupil may be above the edge of the prism, and then the reflected image will be seen at the same time with the paper and pencil. There is a small piece of brass perforated with a hole, and moving on the centre at *a*; this serves to keep the eye in one position, that the image may be steady, and also to regulate the relative quantities of light to be received from the object and from the paper.



The annexed figure shows the instrument on its stand, and clamped to a book. The joint by which the prism is attached to the stand is double. The whole instrument packs in a small box. This instrument serves for drawing objects of all forms, and consequently also for copying lines already drawn on a plain surface. If it is required that the copy shall be of the same size as the drawing, the distance of the drawing from the prism should be the same as the distance of the paper from the eye-hole. No lens will be necessary in this case, because the image and the paper being both at the same distance, coincide.

In order to have a reduced copy of a drawing, the drawing is to be placed at a distance from the prism greater than the distance of the paper from the eye-hole. If the distance is twice as great, a copy will be obtained, in which the lines will be of one-half the size of the lines in the original, and so in proportion to other distances. A lens is necessary, that the eye may be enabled to see at two different distances; and, in order that one lens may serve, the distance between the eye-hole and the paper should be variable; on that account the stand is susceptible being lengthened or shortened.

Camera Obscura (dark chamber), is either a closed room, in which the light can fall only through a small aperture, or an optical box, in which exterior objects are represented on a smaller scale. It is used for amusement, or for drawing landscapes and scenery, though what is gained in rapidity and ease of execution is lost in the dimness of the colouring. (For the theory of this instrument, see Optics.)

Cames are slender rods of cast lead, of which glaziers make their turned or milled lead, for joining the panes or quarrels of glass.

Camp means, generally, the place and order of tents or huts for soldiers in the field. In modern times, a difference is made between *camp* and *bivouac*, the former signifying the residence of an army resting in tents; the latter, the situation of one which dispenses with them, and remains either entirely in the open air, or, where time allows it, in huts built of branches, &c. On the continent of Europe, tents are abolished, and the name of *camp*, therefore, is seldom used there at present.

Camps, of course, are of very ancient origin, since almost all nations, in their infancy, lived as nomades, dwelling in tents; as is the case with many tribes in Asia and Africa at the present day, e. g., the Arabs. The Romans, probably, first carried the art of encampment to a high degree of perfection, on account of their many wars in distant and thinly settled regions, where their large armies found no cities to quarter in. Cæsar and several other Roman authors give us much information on their way of constructing a camp, which they improved in strength and convenience, according to the time they were stationed in it, and which at the same time, the want of fortresses obliged them to make, in some cases, the points of their military operations. From such camps, it is well known, many cities orginated, as Cologne on the Rhine, Treves, Cambridge, Bristol, and many others. It is a fact of much interest, that the military art, after so many changes in tactics, and in the principles of strategy, again resorts to something similar to these fortified camps of the ancients, as in very recent times, it has been thought advisable, besides providing fortresses, properly so called, to strengthen certain large cities on the chief roads, partly in order to defend them against the first attack of the enemy, and to prevent his possessing himself easily of the important resources which they afford, but chiefly to give to retreating armies rallying points, able to furnish support to numerous soldiers. They are also points of assembly for the militia. Thus the Prussians fortified the large city of Cologne. Of all the European armies, the English are the only ones, we believe, who make use of tents, and therefore have camps, in the narrower sense of the word. It is to be observed, that camps have become slighter and simpler with the progress of the military art. The camps of the Turks, or other Asiatic nations, are extremely cumbersome, in comparison with the light bivouac of the Europeans, from which, at any moment, the whole army can rise in arms prepared for battle.

Campaign generally denotes the season during which armies keep the field. It also means an extensive level country. Formerly, when war was not carried on with so much impetuosity as at present, campaigns lasted only during the warmer months; and towards winter, the troops went into winter-quarters, when the officers of the opposing armies often met very amicably at balls and other entertainments; but of late, armies have kept the field through the winter, till a decisive victory has been gained. Thus, the allies, in the winter of 1813—14, followed the French over the Rhine; some battles were fought in January and February, and the armies remained for several months without roof or tent, in the open air of a cold winter.

Campanile; a detached tower, in some parts of Italy, erected for the purpose of containing bells. Several of them have deviated considerably from the perpendicular, in consequence of their great height and narrowness of base. The campanile of Pisa, called *Torre Pendente*, or Hanging Tower, is the most remarkable of these. Its height is 150 feet, and it inclines nearly 13 feet from the perpendicular. The tower consists of eight stories, each of which is surrounded by columns.

Camphor is a white, resinous production, of peculiar and powerful smell, not unlike that of rosemary, and is extracted from two or three kinds of trees of the bay tribe, that grow in the islands of the East Indies and China. Of these, the principal is the *laurus camphora* of Linnæus. It is of considerable height, much branched, and has spear-shaped leaves, with nerves, of a pale yellowish-green colour on the upper side, and bluish-green beneath. The flowers are small, white, and stand on stalks which issue from the junction of the leaves and branches. Camphor is found in every part of the trees; in the interstices of the perpendicular fibres, and in the veins of the wood, in the crevices and knots, in the pith, and in the roots, which afford by far the greatest abundance. The method of extracting it consists in distilling with water in large iron pots, which serve as the body of the still, with earthen heads fitted to them, stuffed with straw, and provided with receivers. Most of the camphor becomes condensed in the solid form among the straw, and part comes over with the water. Its sublimation is performed in low flat-bottomed glass vessels, placed in sand, and the camphor becomes concrete, in a pure state, against the upper part, whence it is afterwards separated with a knife, after breaking the glass. Numerous other vegetables are found to yield camphor by distillation. Among them are thyme, rosemary, sage, elecampane, anemone, and pusatilla. A smell of camphor is disengaged when the volatile oil of fennel is treated with acids; and a small quantity of camphor may be obtained from oil of turpentine by simple distillation, at a very gentle heat. Camphor has a bitterish, aromatic taste, is unctuous to the touch, and possesses a degree of toughness which prevents it from being pulverised with facility, unless a few drops of alcohol be added, when it is easily reduced to a powder. It floats on water, and is exceed-

ingly volatile, being gradually dissipated in vapour if kept in open vessels. At 288° Fah. it enters into fusion, and boils at 400° Fah. It is insoluble in water, but is dissolved freely by alcohol, from which it is immediately precipitated in milky clouds, on the addition of water. It is likewise soluble in the fixed and volatile oils, and in strong acetic acid. Sulphuric acid decomposes camphor, converting it into a substance like artificial tannin. With nitric acid, it yields a peculiar acid, called *camphoric acid*. This acid combines with alkalies, and forms peculiar salts, called *camphorates*. They have not hitherto been applied to any useful purpose. As an internal medicine, camphor has been frequently employed in doses of from 5 to 20 grains, with much advantage, to procure sleep in mania, and to counteract gangrene. In large doses, it acts as a poison. Dissolved in acetic acid, with some essential oils, it forms the aromatic vinegar. It promotes the solution of copal; and from the circumstance that its effluvia are very noxious to insects, it is much used to defend subjects of natural history from their ravages. In a crude state, camphor is formed into irregular lumps, of a yellowish-gray colour, somewhat resembling nitre or bay-salt. It is imported into Europe in canisters, and the refining of it was long kept a secret by the Venetians. The Dutch have since performed this work; and large quantities of camphor are now refined by some of the English and American chemists. For carpenters' work, the wood of the camphor-tree is much used. It is light and durable, and, in consequence of long retaining its aromatic smell, is not liable to be injured by insects. Plants of the camphor and cinnamon trees were captured by Admiral Rodney, in 1782, and afterwards carried to Jamaica, and propagated there. The camphor-tree which grows very abundantly in the western parts of Japan, is a different species from that found in the islands of Sumatra and Borneo, with which we are principally acquainted. Camphor was formerly in great repute as a medicine, but at present its virtues are less highly rated. It is a cordial and stimulant of a decidedly heating character, and is therefore improper in all fevers, unless the system is very low and weak. In such cases, if combined with nitre and other cooling articles, it is sometimes an excellent diaphoretic: but in fevers in general, it is an article rather to be avoided. It was once, however, and is now, in some parts of Europe, thought to be one of the best medicines in fever of almost all sorts; but it is an article that could well be dispensed with in common practice. As a domestic cordial and medicine, it is perhaps more used than any other, being still, in families, a panacea for all ailments of the smaller sort.

CANAL. A canal, in navigation, is an artificial channel for transportation by water. The first inquiry in the project of such a work, accordingly, relates to the amount of transportation that will be accommodated by the route proposed, at some given rate of tolls (for the quantity will be in some degree influenced by that rate). If the project be a mere speculation, or investment of capital by individuals for the sake of income, its expediency will be determined by the net amount of annual tolls it will probably yield; which ought, in this view of the matter, to be equal to the ordinary rate of interest. But the general utility or public expediency of a project of this sort is not determined wholly by this mode of calculation; for, in this view, we must look at the indirect advantages, such as the increased value of lands on the borders of the canal, the increased profits of other works connected with or affected by the one proposed; as in the case of the smaller branches of internal navigation in England, many of which, as will be seen by referring to the subjoined list, are not very productive investments, but doubtless contribute to the large income of the great lines of transportation between the principal towns, as London and Liverpool, by increasing the amount of goods that pass along those lines. To determine the general public utility of one of these smaller branches, therefore, we must estimate not only the increased value which it gives to coal mines, stone quarries, forests, &c. on the borders, but also its effects in enhancing the value of other canals. But a work of this sort may be, on the whole, of public utility, although an absolute income, in consequence of the investment, can nowhere be traced, but only a reduction of the cost of some article of general use, by means of a diminution of the labour, the number of days' or hours' work, necessary to furnish the article, at any place. Thus the proprietors of the Duke of Bridgewater's Canal are under obligation to supply the inhabitants of Manchester with coals at the rate of four-pence for 140 pounds, which is a great benefit to the inhabitants of that town. This is one of the advantages of this work, which should be taken into the account in estimating its public utility. Another beneficial consequence of any great improvement of this description, as well as those of other kinds, often is to promote some species of arts: for instance, a canal may promote agriculture, horticulture, &c., by irrigation or opening a market. In determining on any canal project, then, as well as in estimating its utility, these various circumstances are to be taken into consideration. The motives, whether of public utility or private emolument, or a union of them both, being sufficient to induce to the undertaking, the next things to be considered are, the obtaining of an adequate supply of water, the particular route to be taken, and the mode of construction. On these subjects, the reader is referred to the treatises more particularly relating to them. The remainder of the present article will be devoted to a general account of some of the most considerable works of this sort in various parts of the world.

CANALS OF EGYPT. Egypt has been celebrated for its canals from the earliest periods of history. The principal are the *Canal of Alexandria*, between that city and Rosetta and the Nile; that of *Jessuf*, on the western bank of the Nile, and parallel to it; and that of the *Red Sea and Nile*, across the isthmus of Suez. The existence of this last, though a subject heretofore of some discussion, is now established beyond doubt. It was begun by Necho, son of Psammeticus, about 616 B. C., and the work was continued by Darius Hystaspes, but was afterwards abandoned, from fear of inundating a great part of Egypt, which is supposed to be lower than the surface of the Red Sea. The work was, however, resumed, and completed nearly a century afterwards, about 521 years before the Christian era, by Ptolemy II.; but a current from the Red Sea upon Egypt was prevented, it seems, by a barrier or bank across the canal; or a part of the route may have been left not excavated. This dam, if narrow, might have been passed by boats on inclined planes, after the Chinese method,

or otherwise; but it seems to be more probable that boats did not pass between the canal and the Red Sea, but that the cargoes were carried by land across the intervening barrier, or portion of ground not excavated, and reshipped. Herodotus says this canal was of four days' navigation, and wide enough to admit of four vessels to pass abreast. Strabo says it was 100 cubits wide, and of sufficient depth for large vessels. The breadth would probably vary very much, as does that of the canal of Alexandria; for if it was made, for any considerable part of the distance, by embanking, instead of excavating, additional breadth might be given without increasing the expense of construction; and if navigated by sailing-vessels, like the canal of Alexandria, the additional breadth would be convenient, though not maintained through the whole route.

The *Canal of Jessuf* leaves the Rosetta outlet of the Nile, near Rhameneh, passes a little south of Demanhour (the ancient *Hermopolis Parva*), and thence by the north-east shore of the lake Mareotis to Alexandria. Two branches pass off in a north-west direction, and one in a southwardly, which communicates with the lake Mareotis. This canal is navigated by sailing-vessels, being in most parts of a convenient breadth for this purpose, though at its entrance from the Nile by its new channel, it is only 19½ feet wide. The old entrance, a little north of the new, is not used, on account of the height of the banks, which intercept the wind. Afterwards, at the village of Lemedis, it spreads to the breadth of about 55 yards, and keeps this breadth for 2½ leagues, where the banks are 13 feet above the bottom of the canal, and 10 above the surface of the ground. Passing over 2 leagues more, towards Alexandria to Gabel, the breadth is contracted to 22½ yards. It continues of about this breadth for 4 leagues, and is very regular. Beyond Leloha, it widens, varying in the first half league from 109 to 273 yards in breadth. Near Beda, it is 55 yards wide, and the banks 23 feet high. Passing on towards Alexandria, the country sinks by degrees, until the bottom of the canal is on a level with the adjacent territory, and then rises above it, the canal being here formed by embankments; but, for a league before arriving at Alexandria, the ground rises again, so that the canal is here formed by an excavation in the ground. It passes very near the lake Aboukir, on the left, in the course we have been following, and is separated from it, near the western extremity of the lake, only by a wall about 20 feet in thickness. The water must rise 13 feet above the lowest state of the Nile to enter the *Alexandria Canal;* and at high water in the Nile, the water in the canal is about 2 feet deep on an average. The distance, in a straight line, from Rhameneh to Alexandria, is about 15 leagues, but by the course of the canal, 20. The navigation of this canal continues only about 20 or 25 days in the year, during the highest water of the Nile. The French, when in Egypt, were enabled to navigate this canal for six weeks by clearing away about 18 inches of mud near Rhameneh, at the eastern extremity. This canal, which now passes through ruins and deserts, and is navigable for only a few days of the year, was, as late as the fourteenth century, bordered by a wealthy and populous territory, and, in the time of the Roman and Greek empires, was the channel of an extensive transportation.

CANALS OF CHINA. The Chinese seem to have a more extensive inland canal navigation than any other nation, if not greater than that of all other nations. The general course of the rivers is from west to east, the principal of which are the Yang-tse, or Kiang-keo, to the south, the course of which is said to be 2000 miles, and its breadth 2½ miles at a distance of 100 miles from its mouth; and the Yellow River, to the northward, which is represented to be still longer. These two rivers pass into the sea, within 100 miles of each other, though they are more than 1000 miles apart in the interior of the country. The artificial channels of navigation pass in a northerly and southerly direction across the territory lying between the natural streams, thus making lines of communication between these principal rivers and their various branches, which form the natural channels of transportation in the easterly and westerly directions. As these canals pass over the summits of the intermediate territories between the great streams, the different parts of the canals must be upon different levels, and there must, accordingly, be some means for boats to pass from one level to another, which they do mostly by means of inclined planes and rollers, over which they are drawn by men. The ascent and descent, at some of these planes, is 15 feet. The banks of the canals are, in many instances, lined with freestone, and contain sluices to let the water off for irrigating the country and supplying the towns; and in many parts, also, they are beautifully ornamented with trees. The barque in which Le Compte passed from Nimpo on a canal, was 70 feet long and 16 feet broad. The management, repairs, and extension of the canals is a very important branch of the internal economy of the empire, and the description and history of these works is said to occupy 40 volumes; which does not, however, give us a very definite idea of the extent of these records, as we are not told the size of these volumes. Some of the most extensive of their canals have been in operation about 2000 years, having been completed 80 years before the Christian era; and, about A. D. 605, it is said there were completed in the empire 1600 leagues of canal.

The *Imperial Canal*, and the continuation of the line of transportation between Pekin and Canton, of which that forms a part, is most frequently spoken of, though the distance of the whole route is variously stated. Malte-Brun, in his Geography, states it at 1660 miles, but it is stated by others at 920. The navigation over this route occupies about three months. The part of this line called the *Imperial Canal* is said to be about 500 miles in length from the vicinity of Pekin to the Yellow River, which it meets about 25 leagues from the sea, where the river is about a mile wide and 9 or 10 feet deep. This canal is called the *Imperial*, from its being navigated only by the emperor's boats, which Le Compte estimates at 1000 of 100 tons burthen each. Between the Yellow River and Canton, the navigation is interrupted, for about 30 miles, by a mountainous district, causing a portage of that distance.

CANALS OF ITALY. In ancient Italy, besides the *Canal of the Pontine Marshes*, intended as a drain, and used also for navigation, the region about the mouths of the Po was intersected by the *Fossa Augusti*, *Fossa Philistina*, and numerous other canals. It was in Italy that the great improvement, in modern canals, over the ancient and those of China, was first introduced, in 1481, by the construction of locks and

sluices to pass boats from one level to another. It was the invention of two engineers of Viterbo, brothers, whose names have not been handed down. This improvement was soon after adopted in the Milanese territory, under the direction of Leonardo da Vinci, the famous painter, who was also celebrated as an engineer. Inland navigation became so important, that the Italian governments paid great attention to it, and enacted many regulations on the subject, and numerous treatises were published on the construction of locks and the art of making and managing canals. The following are some of the principal canals of modern Italy:—The *Naviglio Grange*, between Milan and the river Tesino, 15 miles in length, 130 French feet broad at the surface, and 46 at the bottom. It was extended to Milan in 1257, and enlarged, in 1269, with a branch of about 11 miles in length, from Abiato southward. The *Martesena Canal* branches off from the right bank of the Adda, near Concessa (ancient *Trizzo*); is 24 miles in length and 33 feet in breadth, and is raised, in some places, by walls and embankments 110 feet above the level of the river. In 1497, five locks were introduced into this canal. The *great canal of Tesino* terminates at Milan. The *Muzza Canal* is drawn also from the river Adda, near Cassano, and re-enters the river at Castiglione, 40 miles distant.

In *Piedmont* are the *Naviglio d'Inéa*, 38 miles in length, uniting the Dora Baltea and the Sessia, with a branch of 13 miles, to the Gardena River; and a canal of 27 miles from Dora Baltea, a little above the falls of the Po, which, passing Trino, unites with the Po four miles below Casal. These two canals are parallel to the Po, and substitutes for it. There are three other short canals in this territory.—In the *Duchy of Mantua* is the *Fossa Puzzola*, 15 miles in length, from the Mincio to the Tartaro, and the *Canal of St. George*, 7 miles long, branching to the Lake of Mantua; also the *Montanaro*, 8 miles from the same lake to the Po, at Borgo Fute; the *fossa Maestra*, 5 miles from Ozoma to the *Canal Montanaro;* and the *Fossero*, from the Mincio, 7 miles.—In the *Duchy of Modena* is a canal 16 miles in length, from Secchia by Modena to Panaro, which has several branches, one 5 miles long.—In the *papal territory* is the *fossa Rangone*, parallel to the Panaro, from which a branch passes off by Conte to Po Mort or Po di Jerana, and the *Canal Di Giovanni Niginales*, 22 miles long. From Bologna to Ferrara is the *Canal Di Naviglio*, 24 miles long, and terminating in the great marshes. There are, besides, many short branches of the canals already mentioned, as well as locks and channels for passing rapids in the navigable rivers.

Canals of Russia. The canals of Russia began with Peter the Great, who had observed their useful effects in Holland. He commenced three. The *Canal of Ladoga*, begun by him A. D. 1718, and finished by the Empress Anne, is 67½ miles long, from the Volk to the Neva, 70 feet broad, and the water 7 feet deep in summer, and 10 in winter.—The *Canal of Vishnei-Voloshólk*, completed under Peter the Great, but much improved afterwards by Catharine, forms a communication by water between Astracan and Petersburg, or between the Caspian and the Baltic, which is effected, as will be seen by referring to the map, by passing from the Caspian up the Wolga, then turning into the river Ivertza; leaving which, the canal passes over to the river Schlina, which flows towards the Baltic into the Lake Martina, from which flows the river Mista, which, after a course of 234 miles, discharges itself into Lake Ilmen, from which issues the Volk, that runs 130 miles, and empties into the lake Ladoga, which again gives rise to the Neva, that discharges itself into the Baltic at Petersburg; so that these three rivers are, in fact, the same stream, passing through three lakes in its course. It is said that 3485 barques have passed through this canal in one year. There are many other canals in Russia, which we have not space to describe. The canals and rivers supply the channels of a very extensive inland navigation in Russia; so that goods may be transported, by rivers and canals, from the frontiers of China to Petersburg, a distance of 4472 miles; and the line of navigation from Astracan to that capital is 1434 miles.

Canals of Sweden. Canals were early opened in Sweden, and the improvement of the inland navigation has always been a subject of great interest to the government. Among the modern canals of this country is that of *Stromsholm*, 60 miles long, the descent 336 feet, the number of locks 25, breadth 18 feet, and depth 4 feet 4 inches.—The *Kindac Canal* and the *Gotha Canal*, intended to open a communication between the lake Wenner and the Baltic, have been commenced under the superintendence of the English engineer Mr. Telford.—The *Canal of Trolhatta* makes a navigable channel round the rapids of Trolhatta, in the river Gotha, consisting of successive cascades, one of 60 feet in height, and, in all, 114 feet, and situated N. E. of Gothenburg, about 45 miles. The project of constructing works, by which to pass these rapids, was long contemplated, and finally accomplished in 1800. These rapids interrupted the navigation of the Gotha for about two miles; and the difficulty of making a canal past them was owing to the banks being bold and rocky, as is usual at falls of such extent. They are now passed by nine locks, mostly excavated out of solid rock. This is considered a gigantic work, and was executed by a private company, for their own emolument, as well as the public benefit.

Canals of Denmark. The principal canal in this country is that of *Keil*, which commences about three miles north of Keil, and passes 20½ miles across the Duchy of Holstein to the river Eydar, which running by Rendsburg, falls into the German Ocean at Jonningen. The Keil Canal thus opens a communication between the two seas. It was begun in 1777, and completed in 1785; is 100 feet broad at the top, 57 at the bottom, and the least depth of water is 10 feet. The descent from the summit towards the Baltic is 25½ feet, and towards the German Ocean 23 feet. It has 6 locks.

Canabs of Holland. This country, it is well known, is intersected in all directions, by canals, which serve for navigation in summer, and roads of ice in winter. The surface of the water in many of these canals, is above that of the surrounding country; the lands of which are drained by pumping the water up into the canals; for which purpose numerous windmills are scattered about the country and kept in operation.

Canals of Germany. The improvemt of inland navigation in Germany has been obstructed by the division of the territory into numerous small jurisdictions, which are in many respects independent of each other.—The canal between *Vienna* and *Neustadt* is 40 miles in length; and that of *Francis*, com-

pleted in 1802, between the Danube and Jeysse, is of the same length, and has three locks.—In Prussia are the *canals of Stecknitz, Planer, Potsdam, Finow, Muhlrose, Frederic William*, and the *Bromberg*. This last was constructed under Frederic the Great, by the engineer Breekenhaaff. It is 16 miles in length, has a descent of 67 feet, and nine locks.

CANALS OF SPAIN. Spain has done almost nothing towards improving its internal navigation. Some canals have been projected, but only a part of the *Arragon Canal* has been completed, consisting of two pieces of canal, both commencing at Navarre. Though this partial execution of the projected navigation has had a sensible effect in promoting the populousness, fertility, and wealth of the neighbouring territory, the work stands still; and there seems to be little prospect of the completion of the project.

CANALS OF FRANCE. The canals of France, next to those of Great Britain, are the most important in Europe, in respect to their extent and the difficulties overcome in their construction. The whole length of canal navigation in France is about 900 miles, or about one-third part of that of Great Britain.—*Canal of Briare*. The first important work of this kind, constructed in France, was the canal of Briare, called also, that of the *Loire and Seine*, because its object was to connect those two rivers. It was 37 years in execution, being begun in 1605, during the reign of Henry IV., and completed in 1642. It is 34½ miles in length. From the Loire, about a mile from Briare, it ascends along the river Frezee, by Ouzonne and Rogny, where are 7 locks; then by Chatillon and Montargis, and near Cepay meets the river Loing, which falls into the Seine. The locks of this canal, 40 or 42 in number, were the first executed in France. They vary from 124 to 164½ feet in length, and from 5 feet 4 inches to more than 13 feet in lift, and are according to some authorities, 14 feet 5 inches, or, according to others, $15\frac{16}{100}$ feet in breadth. The bottom of the canal is $25\frac{}{100}$ wide. It is supplied with water principally by lakes; one of the feeders, that of Privé, is 12 miles in length. The cost of this canal is estimated at 20,000,000 francs, or about 3,700,000 dollars, which, considering the difference in the value of money, is nearly equal to that of the Erie Canal of New York. It is important for the supply of provisions to Paris.—The *Canal du Midi*, or *Languedoc Canal*, makes a communication between the Mediterranean at the city of Cette, and the Atlantic Ocean at the mouth of the Garonne, passing through the province of Languedoc, and is supplied by the rivers Garonne and Gironde, and their tributaries. It was undertaken in 1664, 22 years after that of Briare was completed, and finished in 1680; being 148 English miles in length, from the coast of the Mediterranean to Toulouse, where it meets the Garonne; 64 feet wide at the surface of the water, and 34 or 35 feet at the bottom; rising, at the summit, 200 metres, or about 640 feet above tide-water, and having 114 locks, varying in lift from 4 to 12 feet, and navigated by boats 85 feet long, and from 17 to 19 broad, drawing 5 feet 4 inches of water, and of 100 tons burthen. The reservoir of St. Ferrol is situated at the summit-level, where a body of water more than five French leagues in length is accumulated, for the supply of the canal, from the streams falling from the neighbouring mountains. This reservoir and the basins at Castelnaudary cover 595 acres. The canal passes under a mountain at Beziers, by a tunnel of 720 feet in length, lined throughout with freestone—a kind of construction novel at the time when the canal was made, though now common. The canal is crossed by 92 road-bridges, and has 55 aqueduct bridges. It was completed under Louis XIV., under the direction of François Andreossi, as engineer. It is estimated to have cost 33,000,000 francs, or about 6,160,000 dollars; in comparing which with the cost of similar works in Great Britain and the United States, allowance must, as above suggested, be made for the difference in the value of money, the same nominal cost, in France, being a much greater actual cost in this comparison.

The *Canal of Orleans* was the next in order of time, having been begun in 1675, and completed in 1692, 12 years after that of Languedoc. It branches from the Loire, near to Orleans, 36 miles below the place where the canal of Briare meets that river, and joins the canal of Briare at Montargis, being 45 miles long. One object of its construction was to save the difficult navigation on the Loire, between Orleans and the junction of the canal of Briare with that river, and to open a shorter route of communication between the Lower Loire and Paris. It has 28 locks varying from 136½ to 177½ feet in length, and of lifts from 5 feet 4 inches to 12 feet 7 inches. From the Loire to the summit, the ascent is 98 feet 2 inches. The breadth is from 25 feet 7 inches to 32 feet, at the surface of the water, and the depth from 4½ feet when full, to 2 feet when lowest. The boats are from 96 to 102 feet long, and 18 feet 10 inches broad. The expense of its construction is stated at 8,000,000 francs, or about 1,500,000 dollars.

The *Canal of Loing* is a continuation of the navigation of that of Orleans, and the northern part of that of Briare, commencing from the northern extremity of that of Briare, and extending to the river Seine, terminating in the neighbourhood of Fontainbleau. It was completed in 1723, is 33 miles long, 44 feet broad at the surface, 34 at the bottom, and from 4 to 5 feet deep. The towing-path, on each side, is 6 feet 5 inches broad, outside of which, on each side, is an embankment, like the *levées* on the Mississippi, or the dykes of Holland, 3 feet high, 19 feet broad at the base, and 12 feet 9 inches at the top, to prevent the waters from overflowing during floods. The whole descent is 136 feet 8 inches, divided among 21 locks, which vary in lift from 4 to 7 feet, and in breadth from 15½ to 16. The cost is stated at 2,500,000 francs, or about 466,000 dollars. It was constructed about the same time with the canal of Orleans.

The *Canal of the Centre*, called also that of *Charolois*, and likewise a branch of the "Grand Navigation," completed in 1791, leaves the Loire at Dijon, follows the banks of the Arran, then the left bank of the Bourbonne, and passes by Parce, Genelard, Aire and Blanzey, to the lakes of Monschamin and Longpendu, which form the summit-level, the rise being 240 feet, by 30 locks, in 6300 metres. The summit-level is a distance of 3940 metres, whence the canal descends by the river Dheune, to St. Julian, where it crosses that river, and passes along the right bank by St. Benain, St. Leger, and St. Gilles, to Chagny, leaves the valley of the Dheune, and crosses towards the river Halia, which it follows to its junction with the Soane at Chalons, the descent from the summit being 400 feet by 50 locks, in a distance of 47,000

metres; the whole length of the canal being about 71 miles, the breadth, at the surface of the water, 48 feet, at the bottom 30 feet, the depth of the water 5½ feet, the length of each lock 100 feet, and its breadth 16. The cost of this canal is stated at 11,000,000 francs, or about 2,060,000 dollars.

The *Canal of St. Quinton* unites the Scheldt with the canal of Flanders. It was projected, in 1727, by the military engineer Devieq, but not constructed until 1810. The original plan, which has been very nearly followed, was to proceed from Maquincourt, near the Scheldt, to Mount St. Martin, there pass through a tunnel 3440 toises, or a little more than 3¾ miles long; then follow the valley of Bellinglise and Haut Court to the heights of Tronquoy; there pass through a tunnel 700 toises, a little more than ¾ of a mile in length, coming out at Ledin; making the distance of the summit-level 7090 toises, or a little over 8 miles, of which 2950 are open, and 4140, or more than 4½ miles, subterraneous. The length of this canal is 28 miles; in the rise from St. Quintin to the summit-level, there are 5 locks, and in the descent to Cambray, 17. The cost is stated at 12,000,000 francs, or about 2,250,000 dollars.

Canals of Great Britain. The English were a century after the French in commencing the construction of canals upon a large scale. The first considerable work of this description was the *Sankey Canal*, for which an act of parliament was passed in 1755; the object of the act being the improvement of the navigation of Sankey Brook; which plan was afterwards changed to that of a separate canal of 12 miles in length. While the work on this canal was in progress, in 1758, the Duke of Bridgewater obtained an act of parliament for making Worsley Brook navigable from Worsley Mill to the river Irwell, for the purpose of facilitating the transportation of coals from his estate to Manchester; but seeing the advantages of still-water navigation over that of a river, he conceived the project of a canal over dry land, passing the river Irwell by an aqueduct, and thus making a communication between his coal mines and the town of Manchester on one level. The plan was subsequently extended, and the duke, who lived 14 years after the commencement of the execution of his project (he died in 1772, at the age of 56), devoted his time and his fortune to the execution of this great work, with the assistance of an engineer distinguished for his genius. He diverted all his resources into this channel, and to enlarge his means for the undertaking, he limited his personal expenses to 400*l*. a year, and is even supposed to have shortened his life in consequence of the toils and anxiety attendant upon so arduous an enterprise. It was a grand project, worthy of the sacrifices he made to it. And it is a stupendous monument, whereby his memory is associated with the wealth and prosperity of our country. The works were projected by the celebrated engineer John Brindley, and executed under his direction, and constitute a lasting memorial of his genius and skill. The difficulties he had to encounter are of so interesting a nature, that we had better give a description of his labours somewhat more in detail. The principle laid down at the commencement of this business reflects much honour on the noble undertaker, as well as upon his engineer. It was resolved that the canal should be perfect in its kind, and that, in order to preserve the level of the water, it should be free from the usual obstructions of locks. But, in accomplishing this end, many difficulties occurred, which were deemed insurmountable. It was necessary that the canal should be carried over rivers, and many large and deep valleys, where it was evident that such stupendous mounds of earth must be raised, as could scarcely, it was thought, be completed by the labour of ages: and, above all, it was not known from what source so large a supply of water could be drawn, as, even upon this improved plan, would be requisite for the navigation. But Mr. Brindley, with a strength of mind peculiar to himself, and being possessed of the confidence of his great patron, who spared no expense to accomplish his favourite design, conquered all the embarrassments thrown in his way, not only from the nature of the undertaking itself, but by the passions and prejudices of interested individuals: and the admirable machines he contrived, and the methods he took, to facilitate the progress of the work, brought on such a rapid execution of it, that the world began to wonder how it could have been esteemed so difficult. Thus ready are men to find out pretences for lessening the merit of others, and for hiding, if possible, from themselves, the unpleasant idea of their own inferiority.

When the canal was completed as far as Barton, where the Irwell is navigable for large vessels, Mr. Brindley proposed to carry it over that river, by an aqueduct of 39 feet above the surface of the water. This, however, being generally considered as a wild and extravagant project, he desired, in order to justify his conduct towards his noble employer, that the opinion of another engineer might be taken; believing that he could easily convince an intelligent person of the practicability of his design. A gentleman of eminence was accordingly called in; who, being conducted to the place where it was intended that the aqueduct should be made, ridiculed the attempt; and when the height and dimensions were communicated to him, he exclaimed, "I have often heard of castles in the air, but never before was shown where any of them were to be erected." This unfavourable verdict did not deter the Duke of Bridgewater from following the opinion of his own engineer. The aqueduct was immediately begun; and it was carried on with such rapidity and success, as astonished all those who but a little before condemned it as a chimerical scheme. This work commenced in September, 1760, and the first boat sailed over it on the 17th of July, 1761. From that time, it was not uncommon to see a boat loaded with forty tons drawn over the aqueduct, with great ease, by one or two mules; while below, against the stream of the Irwell, persons had the pain of beholding ten or twelve men tugging at an equal draught; a striking instance of the superiority of a canal navigation over that of a river not in the tideway. The works were then extended to Manchester, at which place the curious machine for landing coals upon the top of the hill, gives a pleasing idea of Mr. Brindley's address in diminishing labour by mechanical contrivances.

The following are the principal canals in Great Britain:—

(Originally *denotes the first assumed cost per share, where the actual cost is not ascertained.*)

Name.	When made.	Length in miles.	Ascent & Descent, in feet and decimal parts. Total.	Pr. mile.	Breadth.	Depth.	
Aberdare, . . .	1793	$7\frac{1}{4}$	40	5.5			From Glamorganshire to Abernant. Length of the boats, 12 feet; breadth, 5. Number of shares, 221; originally, 100*l.*
Aberdeenshire,	1805	19	170	8.8	20	$3\frac{1}{2}$	From Aberdeen Harbour to Don River, at Inverary Bridge; 17 locks.
Andover, . . .	1790	$22\frac{1}{2}$	177	7.8			From Southampton Water to Andover; has been partially abandoned. Number of shares, 350; originally, 100*l.*
Ashby-de-la-Zouch.	1805	$40\frac{1}{4}$	224	5.6			From the Coventry Canal, at Marston Bridge, to an iron railway, $3\frac{1}{2}$ miles long, at Ticknall. The first 30 miles are level, forming, with the Coventry and Oxford Canal, a level of 73 miles, without including the branches. It has tunnels at Ashby-de-la-Zouch and Snareton (the length of the two is 700 yards), and an iron railway, 6 miles in length, to the Cloudshill mines. It has 2 aqueduct bridges. At Boothorpe, a steam-engine is erected, to convey the water to a feeder for the summit-level. Number of shares, 1482; cost, 113*l.*; price in 1833, 74*l.*
Ashton-under-line, or Manchester and Oldham, and branches,	1797	18	152	8.4	33 15	5	From Rochdale Canal, at Manchester, to Huddersfield, at Duckenfield; has 3 aqueduct bridges; boats of 25 tons burthen. Number of shares, 1760; average cost, 97*l.* 18*s.*; price in 1833, 120*l.*
Barnesley and branches,	1799	18	120	6.7			From river Calder, below Wakefield, to Barnby Bridge; has 1 aqueduct bridge and 20 locks. Number of shares, 720; cost, 160*l.*; price in 1833, 247*l.*
Basingstoke, .	1790	37	195	5.3			From Wye to Basingstoke; has 72 bridges and 29 locks. Number of shares, 1650; cost, 100*l.*; price in 1833, 5*l.* The Tingis branch is $5\frac{1}{2}$ miles in length. The boats are of 45 tons burthen. It has a tunnel of $\frac{3}{4}$ mile.
Birmingham, .	1772	$22\frac{1}{2}$	204	9.07	40	$4\frac{1}{2}$	Commences in the Birmingham and Staffordshire Canal, and terminates in the Birmingham and Fazeley Canal. The boats are 70 feet long and 7 wide, and of 22 tons burthen. Number of shares, 4000; originally, 17*l.* 10*s.*; price in 1833, 239*l.* The tonnage is not to exceed $1\frac{1}{2}$*d.* per mile.
Birmingham and Fazeley,	1790	$16\frac{1}{2}$	248	15	30	$4\frac{1}{2}$	From the Coventry Canal, at Whittington Brook, to Birmingham Canal, at Farmer's Bridge; has 44 locks; boats 22 tons burthen.
Brecknock and Abergavenny,	1776	33	68	2			From the Monmouthshire Canal to Brecon. There is, at Abergavenny, an iron railway a mile in length; at Wain Dew another $4\frac{3}{4}$ miles, and at Llangroiney another $1\frac{1}{4}$ mile. It has a tunnel of 220 yards, and 3 aqueduct bridges. Number of shares, 958; originally, 150*l.*; price in 1833, 80*l.*
D. of Bridgewater	1758	40	83	2	52	5	From the tide-way of the Mersey, at Runcorn Gap; and at Longford Bridge divides into 2 branches, one terminating at Manchester, the other at Pennington, near the town of Leigh. The whole lockage is the 83 feet at the Mersey, in rising from tide-water, by 10 locks. This canal, with a part of the Trent and Mersey Canal connected with it, makes a level of 70 miles, 30 of which are on this canal. Mr. Cary states that there are about 16 miles of canal under ground within the mountains at Worsley. It has 3 principal aqueduct bridges, and several smaller ones. Arched branches pass off from it at considerable distances, under the town of Manchester, from one of which coals are hoisted up to supply the inhabitants, which the proprietors, successors to the Duke of Bridgewater, are bound to furnish them at 4*d.* for 140 lbs.; an advantage to which much of the prosperity of that town has been attributed. The embankment over Stratford Meadows is 900 yards long, 17 feet high, and 112 feet wide at the base; that at Barton Bridge is 200 yards long and 40 feet high. The tonnage is 2*s.* 6*d.*

Name.	When made.	Length in miles.	Ascent & Descent, in feet and decimal parts. Total.	Pr. mile.	Breadth.	Depth.	
Bristol and Taunton,		41					From Taunton Bridge to the mouth of the Avon, below Bristol, price in 1833, 70*l*.
Burrowstonness,	1790	7					
Caistor, ...	1793	9					From Anchole to Caistor.
Caldon and Uttoxeter,		28	136	4.8			A branch of the Grand Trunk Canal, terminating at Uttoxeter.
Caledonian, . .	1822	21⅞	1905	8.6	40 bo.	20	This stupendous canal passes through a chain of lakes, or *locks*, and narrow arms of the sea; and by making 21⅞

miles of canal, and deepening the beds of the rivers Lochy and Oich, and dredging to deepen a part of Loch Nees (in the whole a distance of 4⅛ miles, making the total length of excavation 25 miles, with a lockage, up and down, of 190 feet), an interior navigation of 250 miles is opened across the central part of Scotland, from the Murray Firth, on the eastern coast, to Cantyre, on the western, and about opposite to the northern coast of Ireland; being one-half of the distance of the navigation between the same extreme points, round the northern coast by the Orkneys. It has 27 locks, including the tide-locks, one of them 170, but most, if not all, the others 180 feet long, and all 40 feet wide; thus opening a ship-navigation through the midst of the country, rising, at the summit-level, 94 feet above the tide water of the eastern coast, and 96½ feet above that of the western, showing the ocean to be 2½ feet higher on the eastern. At Fort Augustus, where it leaves Loch Ness in a north-westerly direction, this canal is cut through the glacis of the fortification, thus adding to the military defences as well as to the appearance of the fort, which, with the five locks of masonry rising behind, presents a grand combination of civil and military engineering amid romantic mountain scenery. From Loch Ness, passing in the westwardly direction of the canal to Loch Oich, 1¾ mile, the land is 20 feet above the water line, which, with the depth of water in the canal, makes an excavation, in this distance, of 40 feet in depth, with a bottom of 40 feet in breadth. To save rock-cutting, in descending, in the westwardly direction, as before, from Loch Oich to Loch Lochy, the natural difference of the surfaces of the two lakes being 22 feet, the whole area of Loch Lochy, which is 10 miles in length and 1 in breadth, is raised 12 feet. In the last 2 miles, before the canal in its westerly direction enters Loch Eil, there is a descent of 64 feet, which is passed by 8 connected locks, each 180 feet long by 40 in breadth. These locks are founded on inverted arches, exhibiting a solid and continuous mass of masonry 500 yards in length and 20 yards wide, in which no flaw has yet been discovered. The gates are of cast-iron. This system of locks has received the fanciful appellation of *Neptune's Staircase*; and the appearance of large vessels, with their masts and rigging, descending these stupendous locks, from the hill towards Loch Eil, is most majestic and imposing, exhibiting a striking instance of the triumph of art. In the distance of 8 miles, from Loch Lochy to tide-water in Loch Eil, the canal, in passing along the north-westerly bank of the river Lochy, crosses, by aqueduct bridges, 3 large streams and 23 smaller ones. Since the construction of this canal, upwards of a million of forest trees have been planted along its borders. The cost of this great national work was, for

	£.		£
Management and travelling expenses, .	29,000	Purchase and damage of land, . . .	47,900
Timber, ...	68,600	Horse labour, ...	3,000
Machinery, cast-iron work, &c., . .	121,400	Road-making, ...	4,000
Quarries and masonry, ...	195,800	Incidental expenses, ...	2,000
Shipping, ...	11,000		905,300
Labour and workmanship, ...	418,000	Add, to complete the dredging, . . .	7,200
Houses and buildings, ...	4,600		£ 912,500

Assuming the number of miles operated upon to be 25, the canal cost 36,500*l*. per mile. It was constructed under the direction of Thomas Telford, Esq.

Name.	When made.	Length in miles.	Total.	Pr. mile.	Breadth.	Depth.	
Cardiff, or Glamorganshire,	1775	25	600	24			From a sea-basin on the Severn, near Cardiff, to Merthyr; is connected with various railways, one of which is 26¾ miles long. Number of shares, 600; cost, 172*l*. 13*s*. 4*d*.; price in 1833, 290*l*.
Chester, ...	1775	17½	170	9.7			From the Dee, at Chester, to Nantwich, where it communicates with the Whitchurch branch of the Ellesmere Canal.
Chesterfield, . .	1776	46	380	8.2			From the Trent, at Stockwith, to Chesterfield; has 65 locks and 2 tunnels, together 2850 yards long, and 9½ feet wide. The lower part of the canal is navigable for boats of from 50 to 60 tons burthen, and the higher, being but 26 or 28 feet broad, is navigable for boats of only 20 or 22 tons burthen. These boats are 70 ft. long and 7 ft. broad. Number of shares, 1500; cost, 100*l*.; price in 1833, 176*l*.
Coventry, . . .	1790	27	96	3.6			A part of the line of canal between London and Liverpool, price in 1833, 680*l*.
Crinan, ...	1805	9	117	13			From Lake Gilp to Lake Crinan. Number of shares, 1851; cost, 50*l*.; price in 1833, 2*l*. 10*s*.

Name.	When made.	Length in miles.	Ascent & Descent, in feet and decimal parts. Total.	Pr. mile.	Breadth.	Depth.	
Cromford, . .	1794	18	80	4.4	26		From the Erewash Canal, at Langley, to Cromford. It has several tunnels, and passes the river Derwent by an aqueduct 200 yards long and 30 feet high. The arch over the channel of the river is 80 feet broad. Another aqueduct over a branch of the Derwent is 200 yards long and 50 feet high. Each aqueduct cost about 3000*l*. Number of shares, 460; cost 31*l*. 2*s*. 10*d*.
Croydon, . . .	1801	9½	150	15.8			From Grand Surry Canal to Croydon. It has 23 locks. Number of shares, 4546; originally, 100*l*.; price in 1833, 1*l*.
Dearne and Dove,	1804	9½	125	6.6			From the river Dove, between Swinton and Mexburgh to Barnesley Canal. The boats are from 50 to 60 tons burthen. It has two branches, of 3¼ and 1¾ miles in length.
Derby, ...	1794	9	78	8.6	44-24	4	From the river Trent to Derby. Number of shares, 600; cost, 110*l*.; price in 1833, 140*l*. It has a branch, the Erewash, 8½ miles in length.
Dorset and Somerset,	1803	42					From the Kennet and Avon Canal to the river Stour; has a branch 9 miles long.
Dublin and Shannon,	1776	65½					From Dublin, at the mouth of the Liffey, to the river Shannon, near the town of Moy. It passes 24 miles across a marsh, in which the absorbing nature of the soil rendered the work enormously expensive.
Lawtou branch,		21					
Miltoun branch,		7					
Bog of Allen br.,		3					
Edenderry br.,		1					
Kildare br., . . .		6					
Dudley, ...	1776	10½	35	3.3		5	From the Worcester and Birmingham Canal. It has 61 locks; 3 tunnels, one 3776 yards in length, another 623 yards, and the other 2926 yards, all 13½ feet wide; and near one of them, the Laplat tunnel, it passes 9 locks, nearly contiguous. Number of shares, 2060; originally, 100*l*.; price in 1833, 147*l*.
Stourbridge br.,		2					
Dudley br., . . .		1¼					
Edinburgh & Glasgow,		50					This canal is proposed to commence at Leith, in the Forth, and terminate in the Clyde, at Glasgow.
Ellesmere and Chester, and branches,	1804	109	755	6.9			This canal is said to be the first constructed in England for agricultural purposes, as well as trade. It has 1262 yards of tunnelling. Number of shares, 3575; cost, 133*l*.; price in 1833, 75*l*.
Erewash, . . .	1777	11¾	181	15.4			From the Trent to Cromford Canal; price in 1833, 750*l*.
Fazeley, ...	1790	11					Is a part of the Liverpool line, joining the Grand Trunk with the Coventry Canal. It is entirely level. The Fazeley and Birmingham, and the Birmingham, are continuations of this.
Forth and Clyde,	1790	35					From the tide-water, at the junction of the river Carron with the Forth, to Glasgow. It was the first considerable work of the kind undertaken in Scotland, having been commenced in 1777, and completed in 1790. It ascends, from the Forth to the summit, by 20 locks, 156 feet, in 10½ miles, and keeps this level 18 miles, to Glasgow, and, one mile beyond that city, terminates in the Monkland Canal basin. About 2¾ miles north of the port of Dundas, near Glasgow, a branch of the canal passes off 8¼ miles, crossing the Kelven by a magnificent stone aqueduct, to the tide-water at Bowling Bay, to which it descends by 19 locks, 74 feet in length, and 20 in breadth. When full, it has 8 feet of water; price in 1833, 540*l*.
Glasgow branch,		2¼					
Foss Dyke, . .		11	0	0			From the Trent, at Torksey, to the Witham. It is a level.
Glasgow and Saltcoats,	1812	33¼	168	5			
Glenkenns, . .	1802	27					From the Dee, at Kirkcudbright, to Dalry.

Name.	When made.	Length in miles.	Ascent & Descent, in feet and decimal parts. Total.	Pr mile.	Breadth.	Depth.	
Gloucester, . . Hockcrib branch,	1793	18½ 2			70	15 to 18	A channel for ship navigation, to avoid the windings of the Severn from Berkley Hill, where it leaves that river, to Gloucester, where it joins the river again. Number of shares, 1960; price in 1824, 100*l.*, and a loan of 60*l.* per share, making the investment 160*l.* per share.
Grand Junction, Paddington br., 6 other branches,	1805	93½ 13¾ 40	587	6.3	36 24	4½	A part of the line between London and Liverpool, from Brentford to the Oxford Canal at Braunston. It has 101 locks; passes the river Ouse and its valley by an embankment about half a mile in length, and 30 feet high. It has a tunnel at Blisworth, 3080 yards in length, 18 feet high, and 16½ wide; and another at Braunston, 2045 yards long, the other dimensions being the same as those of the Blisworth tunnel. Number of shares, 11,657½; originally, 100*l.*; price in 1833, 230*l.*
Grand Surrey,	1801	12					From the Thames, at Rotherhithe, to Mitcham. It is of large dimensions, being navigable by the Thames boats. The company pays to the Corporation of London, annually, 60*l.* for the junction of the canal with the Thames.
Grand Western, Tiverton branch,	1796	35 7					From the mouth of the Ex, at Topsham, to Taunton Bridge. Number of shares, 3096; cost, 79*l.*; price in 1833, 28*l.*
Grand Trunk, Its branch, . . .	1777	93 37	642	6.9			A part of the line between London and Liverpool. It has 4 tunnels, in length 3940 yards, and 9 feet wide. Number of shares, 1300½; price in 1824, 2150*l.* The tonnage is from 3*d.* to 4½*d.* per mile.
Grand Union,		23¼	130	5.5			From the Leicester and Northampton Union Canal, near Foxton, to the Grand Junction, east of Braunston Tunnel. Number of shares, 1521; cost, 100*l.*; price in 1824, 50*l.* The canal has, besides, a loan, at 5 per cent. interest, of 19,327*l.*
Grantham, . .	1799	33¾	148	4.4			From the Trent, near Holme Pierpoint, to Grantham. It has divided 8 per cent., and left a clear surplus of 3000*l.* to meet unforeseen accidents. Number of shares, 749; cost, 150*l.*; price in 1833, 195*l.* It is supplied with water wholly from reservoirs.
Haslingdon, . .	1793	13					From the Manchester, Bolton, and Bury Canal, at Bury, to the Leeds and Liverpool, at Church.
Hereford and Gloucester,	1790	36½	225	6.1			From the Severn, at Gloucester, to the Wye, at Hereford. It has 3 tunnels, of 2192, 1320 and 440, making in all 3952 yards. In consequence of the opening of this canal, the price of coals at Ledbury was reduced from 24*s.* to 6*s.* per ton. Shares, originally, 100*l.*; price in 1824, 60*l.*
Huddersfield, .	1798	19½	770	39.5			From Ramsden's Canal, at Huddersfield, to the Manchester, Ashton, and Oldham Canal, at Duckenfield Bridge near Marsden. It has a tunnel of 5280 yards in length. Number of shares, 6312; cost, 57*l.* 14*s.*; price in 1833, 25*l.*
Kennet and Avon,	1801	57	263	4.6			From the Avon, at Dole-mead, near Bath, to the Kennet and Newbury. It has an aqueduct bridge over the Avon. The boats are of 25 or 26 tons burthen. Number of shares, 25,328; cost, 35*l.* 5*s.*; price in 1833, 26*l.*
Kingston and Leominster,	1797	45¾	544	11.8			From the Severn, at Areley, to Kingston. It has two tunnels of 3850, and 1250, making 5100 yards.
Lancaster, . . .	1799	76	287	3.8		7	From Kirby Kendall to Houghton. It has tunnels at Hincaster and Chorley, 800 yards long in the whole. It passes the Loyne by a stone aqueduct, 50 feet high, on 5 arches, each of 70 feet span. It has also a road aqueduct, near Blackmill, 60 feet high. The boats are 56 feet long and 14 broad. Number of shares, 11,699½; cost, 47*l.* 6*s.* 8*d.*; price in 1833, 22*l.*
Leeds and Liverpool,	1771	130	841	6.4	42	4½	From Liverpool to Leeds. The boats navigating between Leeds and Wigan are of 42 tons burthen; those below Wigan, and on this side Leeds, of 30 tons. The tunnels at Foulbridge and Finnloy are, in the whole, 1609 yards long. It has a beautiful aqueduct bridge over the Ayre. The locks are 70 feet long and 15½ wide. The number of shares is 2897¾; originally, 100*l.* each; price in 1833, 455*l.* Tonnage on merchandise, 1½*d.* per mile; on coals and lime, 1*d.*; on stone, ½*d.*

Name.	When made.	Length in miles.	Ascent & Descent, in feet and decimal parts. Total.	Pr. mile.	Breadth.	Depth.	
Leicester, . . .		21½	230	10.7			From the Loughborough basin to the Soar, which has been rendered navigable as far as Leicester. Number of shares, 545; cost, 140*l.*; price in 1833, 190*l.*
Leicestershire and Northamptonshire Union,	1805	43¾	407	9.3			From Leicester to Market Harborough. It has 4 tunnels, 1056, 990, 880, and 286, in the whole 3212 yards in length. Number of shares, 1895; cost, 83*l.* 10*s.*; price in 1833, 88*l.*
Loughborough,	1776	9½	41	4.3			From the Trent, near Sawley, to Loughborough. Number of shares, 70; cost, 142*l.* 17*s.* 8*d.*; price in 1833, 1800*l.* This canal affords a striking instance of the mutability of canal property. In 1824, we find the shares at *four thousand pounds each*, they are now reduced to less than half the money, and this reduction may be mainly ascribed to the increased facilities in coast conveyance.
MarketWeighton,	1770	11	35	3.2			
Monkland, . .		12	96	8			A continuation of the Forth and Clyde Canal.
Monmouthshire,	1796	17¾	1057	53.5			This canal is remarkable for the extent of its railways and inclined planes. Number of shares, 2409; cost, 100*l.*; price in 1833, 194*l.* It has, besides, a loan of 43,526*l.* at an interest of 5 per cent.
Montgomeryshire,	1797	27	225	8.3			From a branch of the Ellesmere Canal to Newtown. Number of shares, 700; originally, 100*l.*; price in 1833, 85*l.*
Welshpool br., .		3¼					
Neath, ...	1798	14					From the river Neath, at the Giant's Grave, to the Aberdare Canal, at Abernant. It serves for the transportation of copper and lead ore from Cornwall to Glamorganshire. Number of shares, 247; cost, 107*l.* 10*s.*; price in 1833, 285*l.*
North Wilts, .	1798	8½					From the Thames and Severn Canal to the Wilts and Berks.
Nottingham, .	1802	15					From the Trent, at Nottingham, to the Cromford Canal, near Langley Bridge.
Oakham, . . .	1803	5 1	126	8.4			From Melton Mowbray to Oakham. Number of shares, 522; cost, 130*l.*
Oxford, ...	1790	91½	269	2.9	30-16	5	From the Coventry Canal to the river Isis at Oxford, and a part of the grand line between Liverpool and London. It has 3 aqueducts of very considerable magnitude, a tunnel at Newbold 125 yards long, and 12½ feet wide, and one at Fenny Compton 1188 yards long and 9½ feet wide. It rises from the level of the Coventry Canal, in 45½ miles, to the summit at Marston Tolls, 74 feet 1 inch, by 12 locks; and descends from the summit at Claydon, in 35 miles, to the Isis, 195½ feet, by 30 locks. It has 188 stone and brick bridges. It cost 178,648*l.* stock, besides 130,000*l.* loan, above half of which has been paid off. Number of shares, 1786; originally, 100*l.*; price in 1833, 560*l.*
Peak Forest, .	1800	21					From the Manchester, Ashton, and Oldham Canal, at Duckenfield, to the Chapel Milton basin. It has a railway 6 miles long. It passes the Mersey, by a bridge 100 feet high, of 3 arches, each of 60 feet span. Number of shares, 2400; cost, 77*l.*; price in 1833, 74*l.*
Portsmouth & Arundel,	1815	14½					From the river Arun, near Little Hampton, to the bay connected with Portsmouth Harbour. Number of shares, 2520; cost, 50*l.*
Ramsden's, . .	1774	8	56	7			From the Calder and Hebble Navigation to the Huddersfield Canal.
Regent, ...	1820	9	86	9.5			The last link, near London, of the chain connecting that city and Liverpool. It commences at Paddington, from the Grand Junction Canal, and meets the Thames at Limehouse, descending, by 12 locks, to a basin communicating with a ship lock. The locks have double chambers, which are estimated to make a saving of nearly one-half the usual quantity of water. It has two tunnels, one at Maida Hill, 370 yards long, the other under Islington, 900 yards. Number of shares, 12,294; cost, 40*l.* 10*s.*; price in 1833, 16*l.* 10*s.*

Name.	When made.	Length in miles.	Ascent & Descent, in feet and decimal parts. Total.	Pr. mile.	Breadth.	Depth.	
Ripon, ...	1767	7					From the river Ure, at Milby, to Ripon.
Rochdale, . . .	1804	31	613	19.7			From the Bridgewater Canal, in the town of Manchester, to the Calder and Hebble Navigation, at Sowerby Bridge. It has 49 locks, 8 aqueducts, a tunnel of 70 yards in length, and several reservoirs. Number of shares, 5631; cost, 85*l.*; price in 1833, 88*l.*
Royal Irish, . .		68	614	9			From Dublin, in a westward direction, to the Shannon, at Tasmonbarry, nearly parallel to the Dublin Canal, and about 10 miles distant from it. Its greatest elevation above the sea is 307 feet, to which it ascends from Dublin by 26 locks, and descends to the Shannon by 15 locks.
Sankey, ...	1760	12½	78	6.2	48	5	From the Mersey and Irwell Navigation, at Fiddler's Ferry, to Sutton Heath Mines. It has 10 locks, and also a tunnel, near St. Helen's. It was the first canal constructed in England.
Shorncliff and Rye, or Royal Military,	1809	18					From the sea, at Hythe, to the mouth of the river Rother. It is a level, having locks to keep in the water at low tide. It is large enough to receive vessels of 200 tons burthen. Each of its extremities is defended by strong batteries. It was constructed on account of Bonaparte's projected descent on England, and hence its name of Royal *Military* Canal.
Shrewsbury, .	1797	17½	155	9			From Shrewsbury to the Shropshire Canal. One half of the ascent is effected by locks, the other half by inclined planes. It has one tunnel. Number of shares, 500; originally, 125*l.*; price in 1833, 250*l.*
Shropshire, . .	1792	7½	453	60.4			From the Severn, at Coalport, to the Shrewsbury Canal, at Downington Wood. It has several inclined planes and railways, but no locks. Price in 1833, 138*l.*
Somerset Coal,	1802	8½	138	16.2			From the Kennet and Avon Canal, at Monkton Coombe, to Paulton. The boats are 72 feet long and 7 broad. It has 22 locks. Number of shares, 800; original cost, 50*l.*; price in 1833, 170*l.*
Radstock br., . .		7½	138	18.4			
Southampton & Salisbury,	1804	17½					From the Itchin, at Northam, to the Avon, at Salisbury
Stafford and Worcester,	1772	46½	394	8.4	30	5	From the river Severn, at Stourport, to the Grand Trunk Canal. It has 44 locks. Its boats are of 20 tons burthen. It has 3 tunnels. Number of shares, 700; cost, 140*l.*; price in 1833, 550*l.* Tonnage not to exceed 1½*d.* per mile.
Stainforth and Keadby,	1798	15					From the river Trent, at Keadby, to the Don, at Fishlake.
Stourbridge, .	1776	5	191	38.2	28	5	From the Stafford and Worcester Canal, at Stourton, to the Dudley Canal. It has 20 locks. Number of shares, 300; originally, 245*l.*; price in 1833, 190*l.*
Stover, ...	1792	6½	50	8			From the river Teign, at Newtown, to Bovey Tracey.
Chudleigh br., .		5½					
Stroudwater, .	1796	8	108	13.5			From the river Severn, at Framiload, to the Thames and Severn Canal, at Wallbridge. Price in 1833, 510*l.*
Swansea, . . .	1798	17½	366	20.9			From Swansea Harbour to Hen Noyadd. Like the Neath Canal, it serves to transport copper ore from Cornwall to Glamorganshire founderies. Number of shares, 533; originally, 100*l.*; price in 1833, 185*l.*
Llansamlet br., .		3					
Tavistock, . . .	1810	4½	237	52.7			From the river Tamar, at Calstock, to Tavistock. It has a tunnel at Morwellham, 460 feet below the surface. This tunnel led to the discovery of a copper mine. Its boats are 15½ feet in length, and 5 in breadth. Number of shares, 350; originally, 100*l.*
Mill Hill branch,		2					
Thames and Medway,	1800	8½					From the Thames, at Gravesend, to the river Medway; Number of shares, 2670; cost, 42*l.* 9*s.* 5*d.*; price in 1824, 26*l.* This canal has loans to a large amount.
Thames and Severn,	1789	30½	377	12.3	40-30	5	From the Stroudwater Canal to the Thames and Isis Navigation. The boats are of 70 tons burthen, being 80 feet long and 5 broad. It has a tunnel at Sapperton, 250 feet below the top of the hill of rock under which it passes. The bottom of this tunnel is an inverted arch. Price 29*l.*

R 2

Name,	When made.	Length in miles.	Ascent & Descent, in feet and decimal parts. Total.	Pr. mile.	Breadth.	Depth.	
Warwick and Birmingham,	1799	25					From the Warwick and Napton Canal, near Warwick, to the Digbeth branch of the old Birmingham Canal. It has a tunnel at Fazeley 300 yards in length. It has 32 locks.
Warwick and Napton,	1799	15					From the Warwick and Birmingham to the Oxford Canal. Number of shares, 980; originally, 100*l.*; in 1833, 216*l.*
Wey and Arun Junction,		16					From the river Wey, near Godalming, to the north branch of the Arun River Navigation. Number of shares, 905; cost, 110*l.*; price in 1833, 22*l.* 10*s.*
Wilts and Berks,	1801	52	376	7.2			From the Kennet and Avon Canal, at Semington, to the Thames and Isis Navigation. Price in 1823, 4*l.* 10*s.*
Calne branch, . .		3					
Worcester and Birmingham,	1797	29	128	4.3	42	6	From the Severn, at Diglis, below Worcester, to the Birmingham and Fazeley Canal, at Farmer's Bridge. Price 85*l.*
Wyrley and Essington,	1796	23	270	11.6	28	4½	From a detached part of the Fazeley Canal, at Huddlesford, to the Birmingham Canal at Wolverhampton. The boats are of 18 tons burthen. It has 28 locks. Price in 1833, 115*l.*
Hayhead br., . .		5½					
Lordshery br., . .		2¼					
Wyrley Bank br.,		4					
Essington br., . .		1					
Norwich and Lowestoff Navigation,	1829	50			50		The works near Yarmouth open an inland navigation in two directions; one 30 miles, by the Yare, the other 20 miles, by the Waveney, without a lock. The river Yare discharges at Yarmouth, about 30 miles below Norwich,

but the navigation is obstructed by shoals and shifting sands at its mouth. To avoid these obstructions, the river is to be made navigable for sea-borne vessels from Norwich to a place 20 miles lower down the river, called *Reedham Ferry*, where a new cut of 2½ miles is to be made across the marshes, to join the river Waveney at St. Olave's Bridge, whence the water communication proceeds by a small stream (Oulton Dyke), and two lakes (Oulton Broad and Lothing), from the latter connected with the sea by a channel 700 yards long and 40 feet wide, with a sea lock 50 feet wide in the clear, and 24 feet deep, for the purpose of admitting sea-borne vessels. Oulton Dyke, and Oulton Broad, are to be deepened. The lock constructed at the outlet of Lake Lothing makes an artificial harbour, the first that has been formed in England. This lock has folding gates pointing both landward and seaward, so as to admit of vessels passing in or out at any time of tide, and whether the water be higher on the outside or inside.

The great importance of navigable canals to a commercial country like Great Britain, will be a sufficient apology for the length of this article; which has been materially improved by corrections and emendations, obligingly furnished by Mr. Woulf, the celebrated canal agent, but our space will only permit a brief notice of American canals,—what more may be found necessary will have a place under INLAND NAVIGATION.

It appears, from the following outline, that not less than 2500 miles of canal are constructed, or in the progress of execution in the United States, and will probably soon be completed, making a liberal allowance for a suspension of some of the works projected and commenced. The extent of canal in the United States will soon equal that in Great Britain. The canals constructed and now in progress in the state of Pennsylvania have been estimated at a length of 900 miles; very nearly equal to that of the canals of France, but doubtless inferior in the style and durability of execution. The *Welland Canal*, in Canada, is intended for opening a sloop navigation between lakes Erie and Ontario.

The *Middlesex Canal* opens a boat navigation between Boston and the Merrimack river, and runs 28 or 29 miles, in a north-westerly direction, from its outlet into the harbour of Boston, in the town of Charlestown. The *Blackstone Canal* is constructed along Blackstone River from Providence, in Rhode Island, north-westerly 45 miles, to Worcester, in Massachusetts. The *Farmington Canal* leaves the coast of Long Island Sound at New Haven, in Connecticut, and takes a north-easterly course, towards Northampton in Massachusetts, 65 miles distant, where it is to communicate with Connecticut River. A great part of it is finished and in operation, but a portion, towards the north-eastern termination, remains to be constructed.

The *Hudson and Erie Canal* passes from Albany, in the state of New York, along the western bank of Hudson River, until it meets the Mohawk; then runs, in a north-westerly direction, up the south-western bank of that river, to the town of Rome, where it turns more westerly, on a summit-level of about 60 miles, without a lock, and passing in a line corresponding in some measure to the direction of the southern shore of Lake Ontario, and crossing the Seneca and Genesee rivers in its course, communicates with Lake Erie at Buffalo, 363 miles from Albany. This canal is connected with Lake Champlain by the *Champlain Canal*, 63 miles in length; with Lake Ontario by the *Oswego Canal*, about 38 miles long; and with Seneca Lake by the *Seneca Canal*, about 20 miles long. The *Hudson and Delaware Canal* begins at the west bank of Hudson River, near Kingston, in New York, about 85 or 90 miles north of the city of New York, and runs in a south-westerly direction 65 miles, to the Delaware River, near to the north-east corner of Pennsylvania, and the north-west of New Jersey. It then takes a general direction a little to the north-west, and keeps

the northern bank of the Delaware River for 25 or 30 miles, to the entrance of Lackawaxen Creek, from the opposite side; crosses the Delaware at a point about 110 miles north of Philadelphia, and leaving that river, keeps the northern bank of Lackawaxen Creek; then crosses it, in a westerly direction, to Riscis Gap, a distance, added to the former, of between 40 and 50 miles, as nearly as can be estimated from Mr. Tanner's map of Pennsylvania, of 1829. This canal opens the Lackawaxen coal district to Hudson River.

The *Morris Canal*, now in progress, commences at its western extremity, at the river Delaware, near Easton, and passes across the state of New Jersey in a north-easterly, then in an easterly, then in a southerly direction, 86 miles, to Newark, in that state. Its western extremity is at the eastern termination of the Lehigh Navigation in Pennsylvania, and it is intended for the transportation of Lehigh coal to New York. The *Ohio State Canal* commences at the mouth of Sciota River, where it discharges into the river Ohio, and takes a northerly course, for about 306 miles, to Lake Erie, at the mouth of the Cuyahoga river, in the town of Cleveland. This work is in rapid progress.

The *Miami Canal* is also a line of communication between the river Ohio, which it leaves at Cincinnati, and Lake Erie. Its northerly termination is in the Maumee, which discharges into the westerly part of Lake Erie. The proposed length of this canal is 265 miles. It is now in progress. *Illinois and Michigan Canal*. An act was passed in the Legislature of Illinois, Jan. 22, 1829, authorizing commissioners, "as soon thereafter as they could command funds, and might deem it expedient to commence the work, to effect a navigable communication between Lake Michigan and the Illinois River." This is the fourth projected work for making a communication between the great northern and western waters; one of the others being projected by Pennsylvania, from Pittsburgh to Erie, of which a very small part is executed; the other two are undertaken by Ohio, and both in progress. The *Lehigh Canal* commences at the Maunch Chunk Coal Mine, on the river Lehigh, and runs to Easton, on the Delaware; the whole distance of this navigation being 46¾ miles; but a part of it is river navigation, the length of the canal being 37 miles. Its eastern termination at Easton meets the western termination of the Morris Canal in New Jersey. The *Delaware Canal* commences, at its northern extremity, at Easton, about 55 miles in a right line nearly north from Philadelphia, on the north-western bank of Delaware River, the general course of which, for about 50 miles from this place, is south-easterly, when it turns, in nearly a south-westerly direction, about 30 miles, to Philadelphia. This canal, which is still in progress, is to follow the general course of the Delaware, keeping its westerly bank to Morrisville, where it bears off from the river, to avoid a bend, and proceeds, in a pretty direct course, a little to the west of south, to Bristol, on the westerly bank of the Delaware, 19½ miles N.E. from Philadelphia. The *Schuylkill Canal* is constructed on the banks of Schuylkill River, from Philadelphia, about 110 miles, to Mount Carbon, the region of the Anthracite, in Schuylkill County, the general direction being nearly north-west.

The *Union Canal* is to the westward of the town of Reading, in Berks County, Pennsylvania, about 60 miles from Philadelphia, the Union Canal branches off from the Schuylkill Canal in a general south-westerly direction, first passing up a branch of the Schuylkill, and then down the valley of the Swatara, somewhat circuitously, about 80 miles, to Middletown, a little above the junction of the Swatara with the Susquehanna. *Pennsylvania Canal* commences at Middletown, at the termination of the Union Canal, whence it is proposed to proceed up along the Susquehanna, in a westerly direction, to the Alleghanies, which are to be passed by a rail-road, now in progress, about 50 miles in length, into the valley of the Ohio, where the canal again commences, and is continued to Pittsburg, a distance in the whole, of 320 miles of canal and rail-road; the part of the canal beyond the Alleghanies being already completed, and the part on the eastern side being in progress. The *Little Schuylkill Canal* is 27 miles in length, from the mouth of the Little Schuylkill River to the coal mines. *Conestoga Canal* passes from Lancaster, in Pennsylvania, about 62 miles directly west from Philadelphia, down the Conestoga Creek, 18 miles, in nearly a south-west direction, to Susquehanna River. The *Chesapeake and Delaware Canal*, 18 miles in length, from the Delaware River to Elk River, which discharges into Chesapeake Bay, is of sufficient dimensions for the passage of coasting vessels, in the route between Philadelphia and Baltimore. *Dismal Swamp Canal* is a channel of sloop navigation, between 6 feet deep and 70 wide, along the low land between Chesapeake Bay and Albemarle Sound, and thence to Pimlico Sound. Several branches have been constructed, and the whole is in operation, being a very important work, and somewhat similar to that of the Chesapeake and Delaware Canal.

The *Chesapeake and Ohio Canal* is a gigantic enterprise, in progress, for opening a navigation of 360 miles, from Washington, along the Potomac and its branches, across the Alleghany mountains, and thence down the valley of the Youghiogeny and Monongahela rivers, to Pittsburgh, on the Ohio. The execution of this work was commenced in 1828, at the eastern extremity.

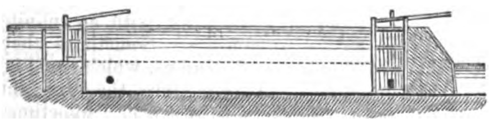
The *Louisville Canal*, though only 3 or 4 miles in length, is a work of great importance as well as great expense. It is now in progress, and is intended to form a passage along the side of the rapids of the Ohio, near to Louisville, in Kentucky. The canal is constructing of sufficiently large dimensions to admit of the passage of steam-boats; and the difficulty and expense, as in the case of the canal at Trolhatta Falls, in Sweden, is occasioned by the necessity of excavating rock. The *James and Kanhawa Canal* is a name given to works intended to form a line of transportation, partly by water and partly by land, from the Atlantic coast to the Ohio; being a navigation along James River to the Blue Ridge, partly by an artificial channel, but mostly by the river, and across the Ridge, by a well-constructed road, graduated to an inclination not exceeding 3 degrees, which has been completed, and descending, by river or canal navigation, along the Kanhawa River to the Ohio. A canal was commenced along the bank of James River, to pass the falls at Richmond, before the revolution. The work was resumed, and completed, after the establishment of the present government, by a private company; but the state has since assumed these works, and greatly enlarged them, upon an improved construction, in

the execution of the plan of the extended line of transportation above described. In Mr. Boye's map of Virginia, the canal is laid down along the north-western bank of the James River, from Richmond to Venture Falls; a distance of about 20 miles, and, by the course of the canal, probably as much as 24 or 25. The *Appomattox Canal* is about 5 miles of canal, in detached portions, being a part of a system of improvement of the Appomattox Navigation in Virginia. The *Roanoke Canal* is a similar work on Roanoke River. The *Santee Canal* is a proposed and partly executed line of navigation from Charleston to Columbia, and thence to Cambridge, in South Carolina. The whole distance is 160 miles. A canal has been cut, and for many years in operation, 22 miles in length, across from Cooper's River, which discharges into the ocean at Charleston, to Santee River. Thence the route of this navigation is proposed to pass along Santee, Broad, and Saluda rivers; the project being an improvement of the river navigation, by removing obstructions, deepening the water in shallow places, and locking round falls. The work has not hitherto been prosecuted with great success. The *Prideaux Canal*, which is a work of great magnitude, and nearly completed, will be described under INLAND NAVIGATION.

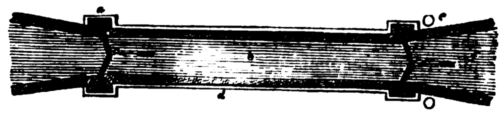
In the preceding account of canals we have studiously avoided every thing connected with the practice of canal digging, and the erection of those stupendous contrivances for facilitating the elevation and depression of vessels in their transit over irregular ground. The canal locks, or water-tight boxes, used for this purpose, hold many thousand gallons of water, and one immense series on the Caledonian Canal have not unappropriately been called the "Giant's Steps."

The Chinese drag their vessels up an inclined plane from a lower to a higher level, which requires powerful machinery, and causes considerable injury to the vessel. Now, if we contrast this primeval process with the arrangement at present pursued, the advantage will be at once apparent. One man, without the aid of machinery of any kind, will raise a barge of fifty tons burthen in a few minutes; and there are few sights better worth witnessing in the neighbourhood of our metropolis than the gratuitous one which is continually presenting itself on the great City Canal.

To render the theory of the canal-lock and its use intelligible to our readers, we must have recourse to a graphic illustration.



The above section of a canal-lock contains the pit, or central chamber, and the gates. The upper level of the canal is shown to the left of the figure, and the lower at the opposite end. Now, if we suppose the two gates connected with the lowest end to be opened, and the barge floated into the chamber, the gates are then closed, and a small channel or underground trap communicating with the higher level opened. The water will immediately enter the chamber, and raise the vessel till it is on the same level with the upper canal; the gates are then thrown open, and the barge floated out. If the object be to lower a barge, a process the reverse of the preceding is pursued. We may suppose the lock filled with water, and the barge in the chamber; the gates are then closed, and an underground passage opened communicating with the lower level; and the water is then let out and the barge sinks; so that on opening the lower gates, the barge can be passed to its destination.



A plan of the canal-lock may render this still clearer: *a* represents the posterns to which the lock gates, *c*, are attached. The walls, *d*, of the lock-pit, *b*, are usually formed of a strong timber or iron frame filled with brick-work. The higher level of the canal, *f*, communicates with the lock-pit by the tunnels *e*, and if there were no gates, the stream would pass in the direction of the arrows.

We must now point out an improvement on the preceding arrangement, adopted on the best canals, but which is attended with nearly double the expense. In the common arrangement, one lock of water is lost each time a vessel is passed, but in the double-lock this is reduced one-half, for the water in the first lock passes to the second, so that while one barge is ascending, another may be lowered, and *vice versa*. To effect this, it is only necessary to open a communication between the two locks, instead of allowing the water to escape from the higher to the lower level each time the double transfer takes place.

CANALIS ARTERIOSUS, in *Anatomy;* the vessel which joins the trunks of the pulmonary artery and the aorta in the foetus.

CANALIS MEDIUS; the canal of communication between the third and fourth ventricles of the brain. Canalis nasalis, the tube which conveys the tears from the lacrymal bag into the nose.

CANCER (the *Crab*), in *Astronomy;* one of the twelve signs of the zodiac, and one of the 48 old constellations ordinarily represented on the globe in form of a crab, and in astronomical books denoted by a figure much resembling that of the number sixty-nine, thus ♋. The reason generally assigned for its name, as well as figure, is a supposed resemblance which the sun's motion in this sign bears to that of the crab-fish. As the latter walks backwards, so the former in this part of his course begins to go backwards, or recede from us; though the disposition of stars in this sign is by others supposed to have given the first hint to the representation of a crab. The Greeks pretend, that when Herculus was contending with the Lernæan hydra, a crab which crawled upon the marsh seized his foot. The hero, however, crushed the reptile to pieces under his heel; but Juno, in gratitude for the offered service, though inconsiderable, advanced the creature to the heavens. Ptolemy makes 13 stars in the sign Cancer; Tycho, 15; Bayen and Hevelius, 29. Mr. Flamstead no less than 83. For an estimate of the comparative brightness of several stars in the constellation Cancer by Dr. Herschel, see *Phil. Trans.* vol. lxxxvii. p. 311, &c. Cancer, *tropic of*, a lesser circle of the sphere parallel to the equator; and passing through the beginning of the sign Cancer. See TROPICS.

CANCER. In medicine, this name is given to a

roundish, unequal, hard, and livid tumour, generally seated in the glandular texture. Though this is the texture in which it is believed always to originate, it may extend to others. This is doubted by some; and the disease which is often met with in the immediate neighbourhood of advanced cancer, and in different textures, is by them ascribed to mechanical pressure of the cancerous tumours, aided by the acrid discharges which accompany its ulceration. The name was derived from a supposed resemblance of the tumour to a crab, and furnishes a good example of the nomenclature from resemblance, which was very much in use in the early periods of the sciences. Two forms of cancer are recognised by physicians. They may rather be called two states or two stages of the same disease. One of these, and the first, is carcinoma, scirrhus, or concealed cancer, of some writers. The second is the open, or ulcerated cancer—ulcerated carcinoma, as it is designated by writers. Under proper internal treatment, the second stage may be kept off for some time; and, in favourable cases, the extirpation of the tumour by the knife may effect a cure. The disease is kept in check, in the first case, but is not removed, and is very prone to pass into the ulcerative stage. The fact that this can be deferred, by proper treatment, is an important one. The sufferings of the patient are thus made less, especially during the first stage; and even in the last their severity is much mitigated.

One very early symptom of carcinoma is pain. This pain differs from that which ordinarily accompanies local diseases of a different kind. It is described as *lancinating*, occurring somewhat in paroxysms, and resembling the suffering which the sudden passage of a sharp and pointed instrument would produce in the part. Besides this, there is always more or less dull pain present. The progress of the disease, and the occurrence of the second stage, are marked by increased pain of both kinds; by increase in the size of the tumour, augmented heat, greater inequality in the surface, a darker colour, and increased tenderness on pressure. When ulceration is just established, and even a little before, the patient complains of general irritation of the skin; the stomach is disturbed; and symptoms of constitutional irritation, more strongly marked, make their appearance. Ulceration begins on the *surface* of the tumour, and parts are destroyed, in succession, from without, until the whole texture presents a mass of disease. Instead of this destructive ulceration, we have, in many cases, fungous masses projecting from the diseased surface; and these at times attain considerable size. But it is not a character of carcinoma to grow, and become as large as other diseases of some of the organs in which it appears. This is especially true of it when seated in the womb. An offensive, sanious discharge proceeds from the ulcer. Bleeding often takes place from it, especially when fungous, either from mechanical irritation, though slight, or from accidental excitement of the arterial system only.

Carcinoma is a malignant disease. Its tendency is to death. The constitution has not power to overcome it; and hence, when left to itself, it is certainly mortal. Internal remedies do little more than palliate symptoms, or prevent the rapid progress to ulceration, which belongs to the disease. The only remedy is the knife; and, in cases in which the constitution and neighbouring parts are not contaminated, extirpation by the knife has removed the disease entirely. There are parts of the body which are liable to carcinoma, in which extirpation cannot be practised, and some in which, though an operation has been performed, death has nevertheless followed. In cases of this sort, especially those of the first class, palliatives only can be resorted to.

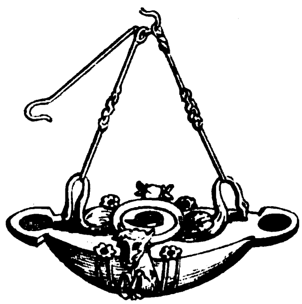
CANDEROS, in the *Materia Medica*, the name of an East Indian gum, not much known among us, though sometimes imported. It has much the appearance of common amber, only that it wants its yellow colour, being white and pellucid; we sometimes see it turned into toys of various kinds, which are very light and of a good polish. Garcias and some other authors tell us, that Borneo, and some other places where camphor is produced, have the art of adulterating the crude camphor, which they send over to us, with large quantities of this gum.

CANDELABRA. The ancients classed under this name a large family of domestic utensils intended for the purpose of holding lights. The "everlasting lights," for sepulchral purposes, as well as those for the use of the heathen altars, were generally of bronze or earthenware, and fed at stated periods by some concealed contrivance. The accompanying figure represents a Roman lamp of bronze, intended to contain a single wick, and we could select no better mode of contrasting the appliances of modern comfort compared with the so-much boasted refinements of antiquity,

than by selecting a simple Argand lamp of the present day, and observing the relative amount of light furnished by it, and the elegant Roman hand-lamp shown in our figure. The first would produce a clear and pure flame, whilst the other would only supply a murky light, poisonous to the atmosphere, and destructive to the furniture of the apartment.

Torches and lamps were the means used by the ancients for obtaining artificial light. The latter were either suspended from the ceilings of their rooms, with chains, or placed upon small moveable tables. The candelabra were originally made of cane, with one plate fixed above and another underneath, or with feet for supporters. The Grecian artists produced, in ornamenting these lamp-stands, the richest forms, which always, however, had reference to the original cane, and were encircled with an infinite variety of beautiful ornaments. Sometimes they were shafts in the shapes of columns, which could be shortened or drawn out; sometimes the luxuriant acanthus, with its leaves turned over; sometimes they represented trunks of trees entwined with ivy and flowers, and terminated by vases or bell-flowers at the top, for the reception of the lamps. Examples of these forms may be found in the British Museum and the Louvre, but particularly at the Vatican, where a gallery is filled with marble candelabra. Candelabra of yet more delicate forms, of bronze, inlaid with silver and other metals, have been found in Herculaneum. In ancient times, Tarentum and Ægina were famous for their elegant candelabra. The graceful and expressive form of this utensil was made use of for colossal works of art, particularly on

account of its resemblance to the holy torches employed in the worship of Æsculapius. The largest and grandest of those monuments was the Pharos, at the harbour of Alexandria. In modern times, this ancient form has been used for an ingenious Christian monument. At the place where the first church in Thuringia was founded by Boniface, the apostle of the Germans, only a few relics remaining of the building, which had served for more than ten centuries as a Christian temple, a candelabrum, 30 feet high, formed of sand-stone, was erected (September 1, 1811), as a symbol of the light which spread from this spot.

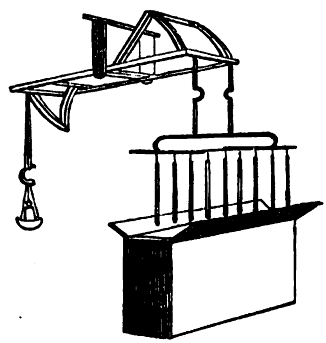


The more beautiful of the ancient candelabra were suspended by chains, and of this form we furnish an example. The Roman candelabra were invariably cast, and as such they were of necessity heavy and cumbrous, but in the present day the same symmetrical effect is produced by "striking-up" of the metal, and the beautiful bronze of antiquity imparted by an acid in a few hours.

While we now write, it is stated in the *London Journal of Science*, that two patents have been taken out in America, for the ornamenting of candelabra by making a thin skeleton of wire, and immersing it in a solution of alum, coloured by metallic oxides. This is, no doubt, a very cheap and beautiful process; the plan has for some time been adopted in the manufacture of ladies' work baskets.

Candle; a combustion of cotton and rush wicks, with various inflammable bodies for producing artificial light. Candles are either formed in moulds or dipped in fluid tallow. In the first case, a series of metal tubes are placed in a frame, and cotton wicks fixed in the centre of each tube. The tallow then descends the tubes, and the "moulds," as they are called, withdrawn as soon as cold.

The other species of candles are called "dips," and the process of dipping candles, by which a determined weight is given to any number, is of comparatively modern invention. We believe that the present Mr. Maudslay laid the foundation of a large fortune by first introducing a weighing machine for the purpose.



It is represented in the figure, and consists of a beam with two quadrants, round which the bands coil at either extremity. One of the bands is provided with a scale-pan, and to the other end of the beam is attached a frame for supporting the candle cottons to be covered with tallow. Now if we suppose the tallow to be raised to the required temperature by a fire at the bottom of the oblong copper cistern, and the cottons immersed, the precise amount of tallow adhering to the wick is shown by the increase of weight necessary to balance it in the scale-pan. When the tallow is cold, the dipping may be repeated till the candles have acquired the proper size.

A patent for an improved mode of manufacturing candles has been lately taken out by Dr. Bulkley, His improvements in making candles consist in two particulars:—first, in making wax candles in moulds instead of forming them by rolling the wax, which is the ordinary way of producing wax candles; and secondly, in making a case of wax shaped like a candle, which is to be afterwards filled with tallow or oil, or other combustible material suitable for making candles.

The first object requires but little farther explanation. To cast wax candle in moulds, it is obvious, that the wax must must be poured into the moulds in a hot and liquid state, and when perfectly cold, the end of the candle is to be struck with a small wooden mallet for the purpose of disengaging it from adhesion to the surface of the mould, when it may be withdrawn.

In putting the second feature of the invention into operation, it is proposed to pour into the candle-moulds the melted wax, as in the previously described process of moulding; and on the wax having cooled and become partially set or hardened, which it will do round the internal surfaces of the moulds before the wax in the central part of the candle has become set, then pour out of the mould the liquid portion of the wax which filled the central part of the candle, and allow the shell of wax thus formed on the surface of the mould to become hard. This shell may then be made the mould in which melted tallow is afterwards poured. There is a third principle spoken of by the patentee, but it is of less importance than those already enumerated.

There is another patent improvement which should be noticed. The main feature of it consists in the use of two small wicks instead of one, and in banding the cotton round with a small metallic spiral of wire. The smallness of the cotton ensures a more perfect combustion than could otherwise be obtained, while the band of wire obviates the necessity for snuffing. We can hardly conceive any thing more simple or efficacious.

Previous to the year 1831, candles had been subject to an excise duty, their consumption therefore could be pretty accurately ascertained. During the year 1829, the total weight of wax, spermaceti, and tallow candles consumed, amounted to 116,206,543 pounds, the net revenue derived from which amounted to 489,059*l.* 1*s.* 9*d.*

To ascertain the illuminating power of different sorts of candles, first weigh one of each sort to be tried; light them all at the same instant; and after the lapse of any given time, say half an hour, extinguish and again weigh them: compare how much each has lost in weight; that which has lost most, is the sort which affords the strongest light.

In order farther to know the comparative expense of burning candles of different kinds, and of various sizes, the reader may consult the following table, which presents the average result of a series of ex-

periments madè with a view to the determination of this point :—

Description of wick.	Number of candles to the pound.	Weight of one candle. oz.	Weight of one candle. dr.	Length of time one candle will burn. H.	Length of time one candle will burn. M.	Time that a pound will last. H.	Time that a pound will last. M.	Expense of burning candles of each description, taking as a suppositive price 10s. per doz. in farthings and 100th parts, whence may easily be deduced the proportional expense, when they are at any other price.
Small wick	18	—	14	3	15	59	25	8.078
Small wick	18	—	13½	2	40	50	33	9.475
Large wick	16	—	15½	2	40	44	—	10.909
	12	1	5¼	3	27	41	32	11.557
	10	1	8	3	36	38	22	12.511
	7	2	1	4	9	32	12	14.907
	8	2	—	4	15	34	—	14.118
	3	2	13	5	19	30	12	15.894
Mould candles, at 12s. per dozen.								
	5	2	12	7	20	42	40	13.502
	4	4	—	9	3	36	12	15.911
	3½	5	2¾	17	30	54	4	10.654

It is curious to mark the number of hours, during which we must of necessity have recourse to artificial light; and we give the substance of some observations made by Mr. Bevan, which accurately defines the limits of day and night for the most interesting months of the year, when the spring is rising beautiful out of the dark grave of winter.

Day.	JANUARY. End, Morning.	Begin, Evening.	Day.	End, Morning.	Begin, Evening.
	H. M.	H. M.		H. M.	H. M.
1	7 31	4 38	16	7 25	4 55
2	7 30	4 38	17	7 24	4 56
3	7 30	4 40	18	7 23	4 58
4	7 30	4 41	19	7 22	5 0
5	7 30	4 42	20	7 21	5 1
6	7 30	4 43	21	7 20	5 3
7	7 30	4 43	22	7 19	5 5
8	7 30	4 44	23	7 18	5 6
9	7 29	4 45	24	7 16	5 8
10	7 29	4 47	25	7 15	5 10
11	7 28	4 48	26	7 15	5 11
12	7 28	4 50	27	7 14	5 12
13	7 27	4 51	28	7 12	5 14
14	7 26	4 52	29	7 10	5 16
15	7 26	4 54	30	7 9	5 18
			31	7 8	5 20

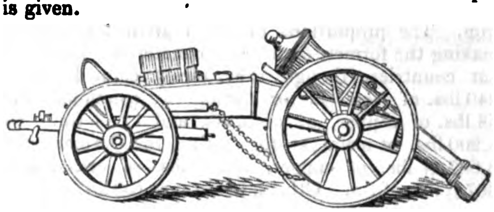
Candil, in *Commerce;* an East Indian weight, equal to 540 pounds avoirdupois.

Canella Alba; the inner bark of the *canella alba*, a tree growing in the West Indies. It is brought to this country packed in casks and cases, in long pieces, some rolled in quills and others flat; the quilled sort is considerably thicker than cinnammon, and the flat nearly a quarter of an inch in thickness. The quilled pieces are yellow on both sides; the flat pieces are yellow on the outside, and pale brown within. The odour of both kinds when fresh broken, is aromatic, something like a mixture of cloves and cinnamon, and the taste slightly bitter, and extremely warm and pungent.

Canis Major (the *Great Dog*), in *Astronomy;* a constellation of the southern hemisphere, below Orion's feet, though somewhat to the westward of him; whose stars Ptolemy makes 29; Tycho only observed 13; Helvelius 51; in the Britannic Catalogue they are 31.

Canis Minor (the *Little Dog*); a constellation of the northern hemisphere. In Ptolemy's Catalogue there are 2 stars; in Tycho's 5; in Hevelius's 13; and in the Britannic Catalogue 14.

Cannon; a heavy metallic gun, which is moved by the strength of men and horses. It is mounted on a carriage, and iron (formerly stone or lead) balls are projected to a distance from it by the force of gunpowder. The interior of the cannon is called the *bore*. The solid piece of metal behind is named the *breech*, and terminates in the *button*. The *dolphins* (so called because they used to be made in the form of this animal) are the handles by which the piece is mounted or dismounted. The aperture through which the fire is introduced into the bore, to ignite the charge, is called the *vent* or *touch-hole*, in which a small tube, used to contain the priming, is placed previous to firing. The supports, which are denominated *carriages*, are mounted on trucks, as in the case of ship-guns or garrison-guns, or on two wheels, as in the case of field-pieces, of which an example is given.

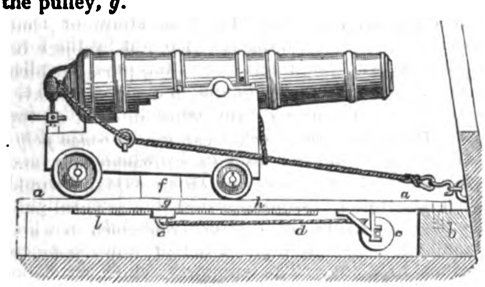


When a field-piece is to be moved, a two-wheeled frame is fixed to the carriage, which is called a *limber*, and this process is called to *limber up*. The charge, or cartridge, is a bag filled with powder, carried near the cannon. The cannon is fired by means of the *match*, which is a lighted bunch of tow, wound round a small stick; or by a tube, filled with the priming-powder, from which a piece is broken off every time, and forced into a stick, to light the charge. On board most of the English ships there are cannon fired by means of locks. To perform the labour required in managing cannon, is called to *serve the guns*.

Cannon were formerly dignified with great names. 12 cast by Louis XII. were called after the 12 peers of France. Charles V. had 12, which he called the *Twelve Apostles*. One at Bois le Duc is called the *Devil;* a 60-pounder, at Dover Castle, is named *Queen*

Elizabeth's Pocket-pistol; an 80-pounder, at Berlin, is called the *Thunderer*; another at Malaga, the *Terrible*; two 60-pounders at Bremen, the *Messengers of Bad News*. In the beginning of the 15th century, names of this sort were abolished, and the following came into general use:—cannon royal, or carthoun, carrying 48 pounds; bastard cannon, or $\frac{3}{4}$ carthoun, 36; half-carthoun, 24; whole culverins, 18; demi-culverins, 9; falcon, 6; saker. lowest sort, 5; ordinary, 6; largest sort, 8; basilisk, 48; serpentine, 4; aspick, 2; dragon, 6; siren, 60; falconet, 3, 2 and 1; moyens, which carried a ball of 10 or 12 ounces: rabinets carried one of 16 ounces. Cannons are at present named from the weight of the balls which they carry, *6-pounders*, *12-pounders*, &c. The length of the cannon is in proportion to the *calibre*.

A ship cannon of the best kind is shown in the figure beneath. The line of timber on the right of the engraving represents the bulwark of the vessel. The cannon being supported by the carriage, *f*, traverses on the plane *a a*, and when it has by its recoil been thrown back sufficiently for loading, it may afterwards be drawn up to the port-hole by a single individual applying his power at the wheel and axle, *c*. The rope, *d*, by which this is effected passes round the pulley, *g*.



Brass cannons, or cannons made of mixed metal, are said not to be so well calculated for hard service, or quick and continued firing, as those made of iron. The proportions of the ingredients used in making the former, do not differ materially in different countries, though they rarely coincide. To 240 lbs. of metal fit for casting, we commonly put 68 lbs. of copper, 52 of brass, and 12 of tin. To 4,200 lbs. of metal fit for casting, the Germans put 3,687 $\frac{4}{11}$ lbs. of copper, 204 $\frac{10}{11}$ lbs. of brass, and 307 $\frac{8}{11}$ lbs. of tin. Others, again, use 100 lbs. of copper, 6 lbs. of brass, and 9 lbs. of tin; and others 100 lbs. of copper, 10 lbs. of brass, and 15 lbs. of tin.

It seems to be the general opinion that cannon were first made use of in 1336 or 1338; but Don Antonio de Capmany has produced some statements, which render it almost certain that some sort of artillery was used by the Moors in Spain, so early as 1312. Cannons were certainly used by the English in 1347, at the siege of Calais, and by the Venetians at Chiaggia in 1366, and in their wars with the Genoese in 1379 and 1380. The Turks employed them at the sieges of Constantinople, in 1394 and 1453. When first introduced, they were for the most part very heavy and unwieldy, and threw balls of an enormous size: they were, however, owing to their frequently bursting, about as dangerous to those using them as to their opponents.

Cannon took their name from the French word *canne* (a reed). Before their invention, machines were used for projecting missiles by mechanical force. These were imitated from the Arabs, and called *ingenia*; whence *engineer*. The first cannon were made of wood, wrapt in numerous folds of linen, and well secured by iron hoops. They were of a conical form, widest at the muzzle. Afterwards, they received a cylindrical shape. At length they were made of iron bars, firmly bound together, like casks, by iron hoops. In the second half of the 14th century, they were formed of an alloy of copper and tin, and in process of time other metals were added. Some attribute the invention of cannon to the Chinese, and say that there are now cannon in China, which were made in the 80th year of the Christian era. From the Chinese the Saracens probably learned to manufacture them, and Callinicus, a deserter from Heliopolis, in Phœnicia, made them known in 670 (676), to the Greek emperor Constantinus Pogonatus.

Bombards were brought into use in France in 1338, and according to another and more doubtful authority, Solomon, king of Hungary, used them in 1073, at the siege of Belgrade. From all these accounts, it appears that the true epoch of the invention of cannon cannot be exactly determined: it is certain, however, that they were actually in use about the middle of the 14th century. In 1370, the people of Augsburg used to cast cannon. In the beginning of the 15th century, nearly all the countries of Europe, except Russia, where cannon were first cast in 1475, were provided with them. The lead cannon which were invented and employed by the Swedes, between 1620 and 1632, in the thirty years' war, were lined with tubes of wood or copper, and secured on the outside with iron rings. The art of firing red-hot balls from cannon was invented by Major-general Weiler, of the Electorate of Brandenburg. In the commencement of the 16th century, Maurice of Switzerland discovered a method of casting cannon whole, and boring them, so as to draw out the interior in a single piece. Arms for expeditious firing, loaded from behind, and having the charge closed in with a wedge, were introduced by Daniel Spekle (who died 1589), and Uffanus. In 1740, cannons were made of ice at St. Petersburg, and balls of many pounds weight were projected without injuring the pieces.

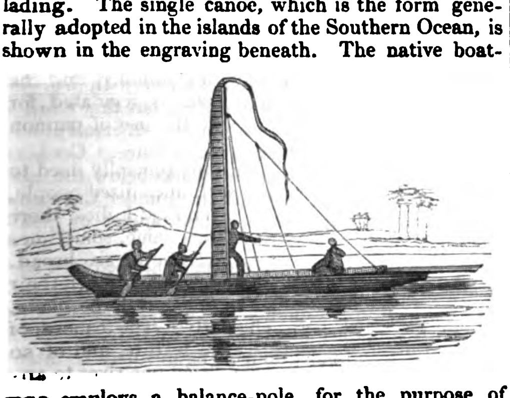
Cannon-clock is a contrivance invented by Rousseau, and placed in the garden of the *Palais Royal*, and in the Luxembourg at Paris. A burning-glass is fixed over the vent of a cannon, so that the sun's rays at the moment of its passing the meridian, are concentrated by the glass on the priming, and the piece is fired. The burning-glass is regulated for this purpose every month. (For the use of cannon in naval warfare, see SHIP.)

CANOE, also CANOA; the term generally used to designate the small vessels which uncivilized people, living near the water use. In the East I dies, there is a kind of boat which goes by this name, sometimes from forty to fifty feet long, and five or six broad. The North American Indians generally impel their canoes with paddles, which have a very large blade, and are managed perpendicularly. The canoes of Canada are of the most fragile texture, and of so little weight, that in passing from one river to another, the boatmen carry them on their heads across their portages. They are mostly covered with bark, the pieces of which are sewed together with a kind

of grass. This bark is generally not more than a quarter of an inch in thickness; yet in these frail vessels the Indians and Canadians do not hesitate to descend very dangerous rapids. The Esquimaux are exceedingly dexterous in the management of their canoes. These consist of a light wooden frame, covered with seal-skins, sewed together with sinews. The skins are not only extended round the bottom and sides, but likewise over the top, forming a complete deck, and having only one opening to admit the Indian to his seat. To this hole a flat hoop, rising about four inches, is fitted, to which is fastened the surrounding skin. The paddle is about ten feet long, light, and flat at each end. A canoe, somewhat similar to this, is found among some of the northern tribes, but which is so curious, as to deserve a particular illustration.

Seal or hippopotamus skins are sewed together, and in some cases a single skin answers the purpose of forming a large and buoyant float. When the air is expelled, the whole canoe may be placed in a very small space, and carried in the fishing-bag of the navigator.

In the Esquimaux language, the canoe is called a *kaiak*, or *man's boat*, to distinguish it from *umiak*, the *woman's boat*, which latter is a large boat for transporting the women, with their families and possessions. The Greenlanders and Esquimaux use the same kind of canoes, and it is astonishing, when we consider their insignificant construction, at what a distance from the regions they commonly inhabit, these people, especially the former, are found in them. In the islands of the South Sea, the natives have a double canoe, united by a strong platform, serving in this way as one vessel. Such a canoe is capable of carrying a number of persons, and a considerable lading. The single canoe, which is the form generally adopted in the islands of the Southern Ocean, is shown in the engraving beneath. The native boat-



man employs a balance-pole, for the purpose of equipoising the action of the wind and weight of the sail, which would otherwise overset the frail barque.

CANON, in *Music*, signified with the ancient Greeks, what now is called *monochord*. At present, it signifies a composition in which the several voices begin at fixed intervals, one after the other, and in which each successive voice sings the verse or the strain of the preceding one. In Italian, therefore, it is called *fuga di consequenza;* in Latin, *canon perpetuus*, or continuous fugue; in German, *Kreisfuge* (circulating fugue). Sometimes each voice begins with the same, sometimes with different notes. Canons may be finite or infinite. The former end, like any other compositions, with a cadence, while the infinite canon is so contrived, that the theme is begun again before the parts which follow are concluded. By this means, the performance might be continued to an indefinite length. A canon may consist of two, three, four, or more voices. Generally only one voice of a canon is written, and a sign shows the place where the other voices are to begin. Formerly, at the beginning of canons, it was the custom to place the directions by which they were to be deciphered and sung. These directions were called the *rule* or *canon*, and thence arises the title which such compositions have since retained. Canons differ from ordinary fugues; for, in the latter, it is sufficient that the subject be occasionally repeated and imitated according to the laws of counterpoint; but in the former, it is essential that the subject be strictly repeated by all the succeeding parts; which repetition may be made in the unison or octave, the fourth, or the fifth, or any other interval of the scale. There are several other canons, as *canon polymorphus*, *canon pertonos*, *canon per diminutionem*, and *canon per augmentationem*, which to explain, would exceed our limits. Sometimes, also, a musical passage of a composition, in which one voice repeats, for a short time, another, is called improperly, a *canon*.

CANOPY, in *Architecture* and *Sculpture ;* a magnificent kind of decoration, serving to cover and crown an altar, throne, tribunal, pulpit, chair, &c.

CANTABILE; a term applied to movements intended to be performed in a graceful, elegant, and melodious stile.

CANTATA; an elegant and passionate species of vocal composition, consisting of an intermixture of air and recitative. It was invented by Barbara Strozzi, a Venetian lady, who flourished about the middle of the 17th century, and was at one time extended to such length as to form a little opera, but has since been cultivated in Italy, Germany, and England, only as chamber music.

CANTEEN (from the French *cantine*, Spanish *cantina*) signifies both a bottle-case and a tavern for soldiers. In military language it denotes a little coffer divided into minute portions for holding an officer's eating utensils; likewise, a semi-cylindric tin case, carried over a soldier's knapsack, to hold his cooked victuals in; also a vessel to hold the ration of spirits or wine served out to the English troops when employed abroad.

Canteen, also signifies a public house, licensed in English barracks or forts, to sell liquors and tobacco to the soldiers.

CANT TIMBERS, in ship-building; those timbers which are situated at the two ends of a ship. They derive their name from being *canted*, or raised obliquely from the keel, in contradistinction from those the planes of which are perpendicular to it.

CANTHARIDES, or Spanish fly, in *Medicine;* the name of a kind of fly, the *cantharis vesicatoria*, Geoffray; *meloë vesicatoria*, Lin.; *lytta vesicatoria*, Fab.; belonging to the family of the *trachelides*. They are very common in Spain, Italy, and France, where they are found in large families on the ash, lilac, liburnum, &c. Their body is from 6 to 10 lines long; the feelers are black, setaceous, composed of 12 articulations; the elytra long, flexible, of a shining, golden green, and the tarses of a deep brown. Their odour is strong, penetrating, peculiar, and unpleasant; their taste extremely acrid; their powder is of a brownish gray, intermixed with shining particles of a metallic green colour. According to Robiquet, they contain, with several other ingredients, a peculiar substance called *cantharidin*. These insects are, of all the vesicating substances, those which are most commonly used. Their action is principally confined to the skin; however, their active principles may be absorbed, and cause serious accidents. The application of a blister is often followed by strangury, hæmaturia, priapism, &c. Taken internally, they act as the most energetic acrid poison; they produce irritation on the intestines, and especially affect the genito-urinary organs, which they stimulate violently. In certain disorders, they are administered in small doses as powerful stimulants. The medicine is of a very dangerous character, and its use requires the greatest caution on the part of the physician. Several species of blistering fly are found in the United States, some of which are more powerful than the Spanish fly.

CANTHARIDIN, the vesicating principle of the *cantharides*, or Spanish fly, is white, in small crystalline scales, insoluble in water and cold alcohol, from which it precipitates by cooling. The vesicating properties could be extracted from cantharides by oil of turpentine, and probably a satisfactory ointment be prepared by merely evaporating the oil of turpentine at a moderate temperature. See CANTHARIDES.

CANVASS, in *Commerce;* a coarse sort of linen or hempen cloth, usually wove open and regularly in little squares; serving for a variety of domestic purposes. Canvass also is the cloth on which painters usually draw their pictures; the canvass being smoothed over with a flat stone, then sized, and afterwards whited over, makes what the painters call their primed cloth, on which they draw their first sketches with a coal or chalk, and afterwards finish with colours.

CAOUTCHOUC. This substance which has been improperly termed elastic gum, and vulgarly, from its common application to rub out pencil marks on paper, *India rubber*, is obtained from the milky juice of different plants in hot countries. The chief of these are the *irtropha elastica*, and *urceola elastica*. The juice is applied, in successive coatings, on a mould of clay, and dried by the fire or in the sun; and when of a sufficient thickness, the mould is crushed and the pieces shaken out. Acids separate the caoutchouc from the thinner part of the juice at once by coagulating it. The juice of old plants yields nearly two-thirds of its weight; that of younger plants less. Its colour when fresh is yellowish-white, but it grows darker by exposure to the air. The elasticity of this substance is its most remarkable property; when warmed, as by immersion in hot water, slips of it may be drawn out to seven or eight times their original length, and will return to their former dimensions. Cold renders it stiff and rigid, but warmth restores its original elasticity. Exposed to the fire, it softens, swells up, and burns with a bright flame. In Cayenne it is used to give light as a candle.

CAPERS; the pickled buds of the capperis spinosa, a low shrub generally growing out of the joints of old walls, and the fissures of rocks, in most of the warm parts of Europe. Capers are imported into Great Britain from different parts of the Mediterranean; the best from Toulon, in France. Some small salt capers come from Majorca, and a few flat ones from about Lyons. The duty of 6*d*. per lb. on capers produced in 1829, 1096*l*. 2*s*. 7*d*. nett, showing that 43,845lbs. had been entered for home consumption.

CAPILLARY TUBES, in *Physics;* little pipes, the canals of which are extremely narrow, their diameter being only a half, third, or fourth, &c. of a line. If one end of a tube of this sort, open at both ends, be immersed in a fluid which adheres to glass, as water, the liquor within the tube will rise to a sensible height above the surface of that without, and the height to which it will rise is inversely as the diameter of the tube, at least unless the tubes are excessively fine. This phenomenon is explained by the attraction which exists between the glass and the fluid. Such liquids as do not adhere to glass do not rise in the tube: on the contrary, they stand lower within than without it. The phenomenon of the rise of liquids in such tubes is exhibited in numberless instances in nature, as in the rising of the sap in plants. See ATTRACTION.

CAPILLARY VESSELS; the minute vessels in which the arteries terminate, and from which, in a way not well understood, the veins commence. The distinction between the arteries and veins is, therefore, lost in these vessels. The support of the solid, and the formation of the fluid parts of the system take place especially in these vessels.

CAPITAL, in *Architecture*. See ARCHITECTURE.

CAPOC; a sort of cotton, so short and fine, that it cannot be spun. It is used in the East Indies to line palanquins, to make beds, mattresses, &c.

CAPONIER, or CAPONNIERE, in fortresses; a place which is covered against the fire of the enemy, on the sides, sometimes also above, and serves for the connection of two works, or for maintaining an important point. In particular—1. a passage secured by two parapets in the form of *glacis*, which leads through the dry ditch from one work to another; for instance, from the chief wall to the ravelin. If danger is to be apprehended only from one side, and consequently only one parapet is made, it is called a *demi-caponniere:* if it is covered above with hurdles or with wood, it is called a *coffer:* but this word is often used indifferently for *caponniere*.—2. Small blockhouses in the covered way for its defence. Coehorn laid out similar, but less useful works below the glacis, and Scharnhorst proposes them under the name of *field-caponnieres*, for the saliant angles of field-fortifications.

CAPRICCIO. *Caprice* is the name applied to a sort of musical composition, in which the composer follows the bent of his humour. The *capriccio* may be used with propriety in pieces for exercise, in which the strangest and most difficult figures may be introduced, if they are not at variance with the nature of the instrument or of the voice.

CAPRICORN (the *Goat*), in *Astronomy;* a southern constellation and the tenth sign of the zodiac, from

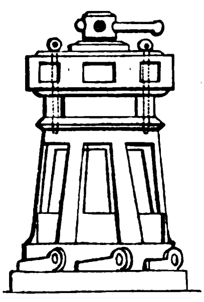
which also the tenth part of the ecliptic takes the same denomination. This was one of the 48 constellations received from the Egyptians by the Greeks. The stars in the constellation of Capricorn, in Ptolemy's and Tycho's catalogue, are 28; in that of Hevelius 29; and Mr. Flamstead, in the Britannic Catalogue, enumerates 51.

CAPSICIN. Cayenne pepper contains a peculiar substance, discovered by Forchhammer, and called *capsicin* by Dr. C. Conwell, which, according to the latter, when perfectly pure, is tasteless, inodorous, and crystallizes in acicular fragments. It is neither acid nor alkaline.

CAPSTAN, in ship building, is a mechanical power employed to facilitate labour in elevating the anchor, and for other purposes in which great force is required. It is a very extraordinary circumstance, that while improvements have been made in every other part of naval machines, but little has been effected in this, and we gladly notice a patent for the above purpose, by Mr. Hindmarsh.

The object of this improvement is to enable a capstan or windlass to be occasionally worked with increased power, which is proposed to be effected by placing toothed gear, partly in the drum-head of the capstan, and partly in the upper part of the barrel.

The drum-head, and also the barrel, turn loosely upon a central spindle, independent of each other, and are connected together either by the toothed gear, or by bolts. On raising or withdrawing the connecting pinion from the toothed wheels, and then locking the drum-head and barrel together, the capstan works with a power, only equal to that exerted by the men at the capstan bars, as an ordinary capstan; but on lowering the pinion into gear with the wheel work, and withdrawing the bolts which locked the drum-head to the barrel, the power exerted by the men becomes increased, in proportion to the diameters and numbers of teeth in the wheels and pinions.



The barrel, with the whelps, turns loosely upon a vertical spindle, fixed into the deck of the vessel. The drum-head also turns loosely upon the same spindle. The circular frame, in which the axis of the toothed wheels are mounted, is fixed to the central spindle. The rim, with internal teeth, is made fast to the top of the barrel; and the pinion which slides upon the spindle, is connected to the drum-head.

CAPUT-MORTUUM (*dead head*); a technical expression in chemistry for the deposit in the retort, arising from dry distillation; because, if the operation is continued, volatile substances cease to be given off.

CARABINE; a term for a kind of gun, which is now out of use. At present, short guns, used by the cavalry, have this name. Tacticians entertain very different opinions respecting this kind of arms. Some think that they are of no use whatever, as the aim from on horseback is extremely uncertain. In some armies, every third man of certain regiments of cavalry is armed with a carabine. The word *carabine* is found in all European languages, with different endings only. Many derive the word from *Calabria*, which, for a long time, was famous for a certain light cavalry. The transformation of the *l* into *r* would not be extraordinary. Du Fresne derives the word from a kind of arms called *chavarina*, of which mention is made in the 14th century.

CARBON. Charcoal, as we are familiar with it in common life, contains hydrogen and saline and metallic substances. Accordingly, it became necessary to introduce a peculiar term for its pure base, and the one adopted by chemists was *carbon*. This element, besides forming the inflammable matter of charcoal, exists largely in animal substances, and is extensively distributed in the mineral kingdom.

The only body in which carbon has been found to exist in a state of absolute purity, is the diamond. This precious stone has always been esteemed as the most valuable of the gems—a superiority which it owes to its hardness, lustre, and high refractive power. Diamonds are brought from India and from Brazil. Those of India, which have been the longest known, are principally found in the kingdoms of Golconda and of Visiapour. Those of Brazil, discovered at the commencement of the 17th century, belong to the district of Serro de Frio. The situations in which they occur are such as to favour the idea of their recent formation; since they exist disseminated through a loose, ferruginous sandstone, or quite detached in a sandy soil; and, in both cases, are situated at no great depth below the surface. In Brazil, the conglomerate in which they exist is called *cascalho*; from which they are extracted by washing, in the same manner as gold. The diamond uniformly occurs crystallized, and presents a great variety of forms; all of which yield readily to mechanical division parallel to all the planes of the regular octohedron, which, therefore, is the form of the primary crystal, and under which figure it is sometimes found in nature. The faces of its crystals are very frequently curved, so as to communicate to them a rounded appearance. They are commonly limpid; and are either colourless, or of a yellowish, bluish, yellowish-brown, black-brown, Prussian blue, or rose-red colour. Specific gravity, 3.5. Its hardness is extreme; so that it can be worn down only by rubbing one diamond against another, and is polished only by the finer diamond powder.

The weight, and, consequently, the value of diamonds, are estimated in carats, one of which is equal to four grains; and the price of one diamond, compared with that of another of equal colour, transparency and purity, is as the squares of the respective weights. The average price of rough diamonds, that are worth working, is about 2*l.* for the first carat. The value of a cut diamond is equal to that of a rough diamond of double weight, exclusive of the price of workmanship; and the whole cost of a wrought diamond of

1 carat	may be about 36 dollars, or		£ 8
2 carats	is	$2^2 \times £8 =$	32
3 do.	is	$3^2 \times 8 =$	72
4 do.	is	$4^2 \times 8 =$	128
100 do.	is	$100^2 \times 8 =$	80,000

This rule, however, is not extended to diamonds of more than 20 carats. The larger ones are disposed of at prices much beyond their value by that computation. The snow-white diamond is most prized by the jeweller. When transparent, and free from cracks, it is said to be of the *first water*.

The following are some of the most extraordinary diamonds known:—one in the possession of the

rajah of Mattan, in the island of Borneo, where it was found about a century ago: it is shaped like an egg, and is of the finest water: its weight is 367 carats, or 2 oz. 169 grs. Troy. Another is the celebrated Pitt diamond, now among the crown jewels of France, weighing 136 carats; another in the sceptre of the Emperor of Russia, of the size of a pigeon's egg; and another in the possession of the Great Mogul, which is said to weigh 280, and which, in a rough state, weighed 793 carats. From the fact that transparent inflammable bodies refract light in a ratio greater than their densities, Sir Isaac Newton conjectured that the diamond might consist of an unctuous matter coagulated. The Florentine academicians had rendered its combustibility probable, by exposing it to the solar rays of a powerful burning-glass, and observing that it gradually disappeared, or was consumed. Subsequent experiments settled the question, by proving that the diamond lost none of its weight when calcined out of contact with the air; but, on the contrary, that it was dissipated when heated in contact with this fluid. It still remained, however, to be discovered, what was the true nature of the diamond. This was accomplished by Lavoisier, who enclosed diamonds in jars filled with atmospheric air or oxygen gas, and, after having caused them to disappear by the heat of a burning-glass, examined the air in the vessels. He found it to exhibit precisely the same properties as the air which results from the combustion of charcoal. This experiment was also performed by Mr. Pepys, who demonstrated the nature of the diamond by another arrangement. A diamond was enclosed in a cavity made in a piece of pure, soft iron; a stopper of the same metal was driven into it, and the mass was put into a small crucible, which was covered, and this into a second; the space between them being filled with pure silicious sand. The whole was exposed, for some time, to an intense heat. When examined, the diamond had disappeared, and the iron, with which it had been in contact, was converted into steel. Now steel is a compound of iron and carbon; and, as the diamond was not visible, and as there was no source from which the carbon could have been obtained, the conclusion was unavoidable, that the diamond was pure carbon. Yet so different is this mineral from charcoal, that it was, for a time, imagined that it contained some other element than carbon; but the numerous and delicate experiments of Sir H. Davy, and several other chemists, failed of detecting any thing else in its composition; and, although there exists so great a difference between the diamond and charcoal, in their external properties, we are forced to believe that they are identically of the same nature. The diamond is, therefore, pure carbon, and differs from charcoal (leaving out of question its trifling impurities) only in the arrangement of its molecules.

The substance in which carbon exists next in purity is charcoal. For common purposes, this is prepared by piling billets of wood in a pyramidical form, with vacuities between them for the admission of air, covering them with earth, and inflaming them. In consequence of the heat, part of the combustible substance is consumed, part is volatilized, together with a portion of water, and there remains behind the ligneous fibre only of the wood, in the form of a black, brittle, and porous body. When required pure, and in small quantities, for the purposes of the chemist, it may be obtained by immersing the wood in sand contained in a crucible exposed to heat. According to the experiments of Messrs. Allen and Pepys, the weight of charcoal obtained from 100 parts of different woods was as follows:—fir, 18.17; lignum vitæ, 17.25; box, 20.25; beech, 15; oak, 17.40; mahogany, 15.75.

Lampblack is charcoal in a state of minute division, and is prepared for the demands of trade from the dregs which remain after the eliquation of pitch, or else from small pieces of fir-wood, which are burned in furnaces of a peculiar construction, the smoke of which is made to pass through a long horizontal flue, terminating in a close, boarded chamber. The roof of this chamber is made of coarse cloth, through which the current of air escapes, while the soot, or lampblack, remains behind. *Coke* is a peculiar kind of charcoal, which remains in the retort, after the heating of coal to procure the coal gas.

Ivory-black, or *animal charcoal*, is obtained from bones made red-hot in a covered crucible, and consists of charcoal mixed with the earthy matters of the bone.

Wood charcoal, well prepared, is of a deep-black colour, brittle and porous, tasteless and inodorous. It is infusible in any heat a furnace can raise; but, by the intense heat of a powerful galvanic apparatus, it is hardened, and at length is volatilized, presenting a surface with a distinct appearance of having undergone fusion. The density of charcoal, according to Mr. Leslie, is little short of that of the diamond itself, although its specific gravity has usually been considered as low as 2.00. Charcoal is insoluble in water, and is not affected by it at low temperatures; hence wooden stakes, which are to be immersed in water, are often charred to preserve them.

Owing to its peculiarly porous texture, charcoal possesses the property of absorbing a large quantity of air, or other gases, at common temperatures, and of yielding the greater part of them when heated. It appears from the researches of Saussure, that different gases are absorbed by it in different proportions. He found that charcoal prepared from box-wood absorbs, during the space of 24 or 36 hours, of

Ammoniacal gas .	90	times its volume;
Muriatic acid . .	85	do.
Carbonic acid . .	35	do.
Oxygen	9.25	do.
Hydrogen . . .	1.75	do.

Charcoal likewise absorbs the odoriferous and colouring principles of most animal and vegetable substances. Thus, all saline substances, which, from the adherence of vegetable or animal extractive matter, are of a brown colour,—as crude tartar, crude nitre, impure carbonate of ammonia, and other salts,—may, after being digested through the medium of water with charcoal, be obtained white by a second crystallization. Resins, gum-resins, assafœtida, opium, balsams, essential oils, and many other substances, even those that have the strongest smell, are rendered nearly inodorous when they are rubbed with charcoal and water, or when solutions of them in alcohol are macerated with the charcoal, or filtrated repeatedly through it. A number of the vegetable tinctures and infusions also lose their colour, smell, and much of their taste, by the same process. Common vinegar, on being boiled with charcoal powder, becomes colourless. Malt spirit, by distil-

lation with charcoal, is freed from its disagreeable flavour. In the same manner wines also become colourless, and distilled waters lose their odours. Water, which, from having been long kept in wooden vessels, as during long voyages, has acquired an offensive smell, is deprived of it by filtration through charcoal powder, or even by agitation with it for a few minutes, especially when a few drops of sulphuric acid have also been added. Hence, also, it has been found that, by charring the inside of casks for keeping water, it may be preserved a long time without spoiling. Charcoal can even remove or prevent the putrescence of animal matter. If a piece of flesh has become tainted, the taste and smell may, in a great measure, be removed, by rubbing it with charcoal powder; and it may be preserved fresh for some time by burying it in the same substance. To produce these effects, however, it is necessary that the charcoal should have been well calcined and newly prepared.

The uses of charcoal are extensive. It is used as fuel in various arts, where a strong heat is required without smoke, as in dyeing, and in various metallurgic operations. By cementation with charcoal, iron is converted into steel. It is used in the manufacture of gunpowder, in its finer state of aggregation, under the form of ivory-black, lamp-black, &c. It is the basis of black paint; and mixed with fat oils and resinous matter, to give a due consistence, it forms the composition of printing ink. It is used to destroy colour and odour, particularly in syrups; to purify honey; to resist putrefaction; to confine heat, and for a number of other important purposes.

When charcoal is heated to a certain degree in the open air, or in oxygen gas, it takes fire, and burns with the production of an elastic vapour, which has been called *carbonic acid gas*. It is usually obtained, however, by other processes. It exists, combined with lime, in the different varieties of limestone, marble, and chalk; and if any of these substances be exposed to a strong heat, the affinity of the acid to the lime is so far weakened, that it assumes the elastic form, and may be collected. An easier mode is also practised for effecting its disunion, through the affusion of one of the more powerful acids. From the experiment of the direct formation of this acid, by the combustion of charcoal in oxygen gas, its composition has been determined to be 27.4 carbon, and 72.6 oxygen. Tennant illustrated its nature analytically, by passing the vapour of phosphorus over chalk, or the carbonate of lime, heated to redness in a glass tube. The phosphorus took oxygen from the carbonic acid, charcoal in the form of a light black powder, was deposited, and the phosphoric acid, which was formed, united with the lime. Carbonic acid is a colourless, inodorous, elastic fluid, which possesses all the physical properties of the gases in an eminent degree, and requires a pressure of 36 atmospheres to condense it into a liquid. Its specific gravity, compared with common air, is 1.5277. It extinguishes burning substances of all kinds, and is incapable of supporting the respiration of animals, its presence, even in a moderate proportion, being soon fatal. An animal cannot live in air which contains sufficient carbonic acid for extinguishing a lighted candle; and hence the practical rule of letting down a burning taper into old wells or pits, before any one ventures to descend. When an attempt is made to inspire pure carbonic acid, a violent spasm of the glottis takes place, which prevents the gas from entering the lungs. If it be so much diluted with air, as to admit of its passing the glottis, it then acts as a narcotic poison on the system. It is this gas which so often proves destructive to persons sleeping in a confined room with a pan of burning charcoal. Lime-water becomes turbid when brought into contact with carbonic acid, from the union of the lime with the gas, and the insoluble nature of the compound thus formed. Hence, lime-water is not only a valuable test of the presence of carbonic acid, but is frequently used to withdraw it altogether from any gaseous mixture that contains it. Carbonic acid is absorbed by water. Recently-boiled water dissolves its own volume of carbonic acid, at the common temperature and pressure; but it will take up much more if the pressure be increased. Water and other liquids, which have been charged with carbonic acid under great pressure, lose the greater part of the gas when the pressure is removed. The effervescence which takes place on opening a bottle of ginger beer, cyder, or brisk champaign, is owing to the escape of carbonic acid gas. Water which is fully saturated with carbonic acid gas sparkles when it is poured from one vessel to another. The solution has an agreeably acidulous taste, and gives to litmus paper a red stain, which is lost on exposure to the air. On the addition of lime-water to it, a cloudiness is produced, which at first disappears, because the carbonate of lime is soluble in an excess of carbonic acid; but a permanent precipitate ensues, when the free acid is neutralized by an additional quantity of lime-water. The water which contains carbonic acid in solution is wholly deprived of the gas by boiling. The agreeable pungency of beer, porter, and ale, is in a great measure owing to the presence of carbonic acid; by the loss of which, on exposure to the air, they become stale. All kinds of spring and well-water contain carbonic acid, which they absorb from the atmosphere, and to which they are partly indebted for their agreeable flavour. Boiled water has an insipid taste, from the absence of carbonic acid. Carbonic acid is always present in the atmosphere, even at the summit of the highest mountains. Its origin is obvious. Besides being formed abundantly by the combustion of all substances which contain carbon, the respiration of animals is a fruitful source of it, as may be proved by breathing a few minutes into lime-water. It is also generated in all the spontaneous changes, to which dead animal and vegetable matters are subject. The carbonic acid proceeding from such sources is commonly diffused equably through the air; but, when any of these processes occur in low, confined situations, as in the galleries of mines or in wells, the gas is then apt to accumulate there, and form an atmosphere called *choke damp*, which proves fatal to any animals that are placed in it. These accumulations take place only where there is some local origin for the carbonic acid; for example, when it is generated by fermentative processes going on at the surface of the ground, or when it issues directly from the earth, as happens at the Grotto del Cane, in Italy, and at Pyrmont, in Westphalia.

Though carbonic acid is the product of many natural operations, no increase of its quantity in the atmosphere is discoverable. Such an increase ap-

pears to be prevented by the process of vegetation. Growing plants purify the air by withdrawing carbonic acid, and yielding an equal volume of pure oxygen in return; but whether a full compensation for the deterioration of the air by respiration is produced in this way, has not as yet been satisfactorily determined.

Carbonic acid abounds in mineral springs, such as those of Tunbridge, Carlsbad, and Saratoga. In combination with lime, it forms extensive masses of rock, which occur in all countries, and in every formation. It unites with alkaline substances, and the salts so produced are called *carbonates*. Its acid properties are feeble, so that it is unable to neutralize completely the alkaline properties of potash, soda, and lithia. For the same reason all the carbonates, without exception, are decomposed by the muriatic and all the stronger acids; the carbonic acid is displaced, and escapes in the form of gas.

Another gaseous compound of carbon with oxygen, called *carbonic oxide*, exists, or may be obtained by heating powdered chalk, or any carbonate which can bear a red heat without decomposition, with iron filings in a gun-barrel. It is evolved together with carbonic acid gas, from which it may be freed by agitating the mixed gases with lime-water, when the carbonic acid is absorbed, and the gas in question is left in a state of purity. It is colourless and insipid. Lime-water does not absorb it, nor is its transparency affected by it. When a lighted taper is introduced into a jar of carbonic oxide, it takes fire, and burns calmly at its surface with a lambent, blue flame. It is incapable of supporting respiration. A mixture of 100 measures of carbonic oxide, and rather more than 50 of oxygen, on being exploded in Volta's eudiometer by electricity, disappear, and 100 measures of carbonic acid gas occupy their place; from which the exact composition of carbonic oxide is easily deduced: for carbonic acid contains its own bulk of oxygen; and, since 100 measures of carbonic oxide, with 50 of oxygen, form 100 measures of carbonic acid, it follows that 100 of carbonic oxide are composed of 50 of oxygen, united with precisely the same quantity of carbon as is contained in 100 measures of carbonic acid. Consequently, the composition of carbonic acid being,

By volume,
Vapour of carbon, 100
Oxygen gas, . . 100
100 carbonic acid gas,

By weight,
Carbon, ... 6
Oxygen, ... 16
22 carbonic acid,

that of carbonic oxide must be,

By volume,
Vapour of carbon, 100
Oxygen gas . . . 50
100 carbonic oxide gas,

By weight,
Carbon, ... 6
Oxygen, ... 8
14 carbonic oxide.

Its specific gravity is 0.9721.

The process for generating carbonic oxide will now be intelligible. The principle of the method is to bring carbonic acid, at a red heat, in contact with some substance which has a strong affinity for oxygen. This condition is fulfilled by igniting chalk, or any of the carbonates, with half its weight of iron filings, or of charcoal. The carbonate is reduced to its caustic state, and the carbonic acid is converted into carbonic oxide by yielding oxygen to the iron or the charcoal. When the first is used, an oxide of iron is the product; when charcoal is employed, the charcoal itself is converted into carbonic oxide.

CARBONIC ACID. See CARBON.

CARBONIC OXIDE. See CARBON.

CARBUNCLE, in *Surgery;* a roundish, hard, livid, and painful tumour, quickly tending to mortification, and (when it is malignant) connected with extreme debility of the constitution. When this complaint is symptomatic of the plague, a pestilential bubo usually attends it. (See PLAGUE.) The carbuncle is seated deeply, in parts provided with cellular membrane, and therefore does not soon discover its whole dimensions, nor the ill digested matter it contains.

CARCASS (in French, *carcasse*), in military language; an iron case filled with combustible materials, which is discharged from a mortar, like a bomb. There were formerly two kinds, oblong and round ones, but they are now out of use.

In architecture, *carcass* signifies the timber-work of a house, before it is either lathed or plastered.

CARCINOMA. See CANCER.

CARDIACUS PLEXUS, in *Anatomy*, is formed by the nerves which supply the heart, and which are derived from the superior and inferior cervical, and first dorsal ganglia of the great sympathetic nerve from the par vagum and the recurrent nerve.

CARDINAL POINTS; the four intersections of the horizon with the meridian and the prime vertical circle. They coincide with the four cardinal regions of the heavens, and are, of course, 90° distant from each other. The intermediate points are called *collateral points*.

CARDING; a preparation of wool, cotton, hair, or flax, by passing it between the iron points, or teeth, of two instruments, called *cards*, to comb, disentangle, and arrange the hairs or fibres thereof for spinning, &c. Before the wool is carded, it is coated with oil, whereof one-fourth of the weight of the wool is required for wool destined for the woof of stuffs, and one-eighth for that of the warp.

CARDS, PLAYING, are pieces of thin pasteboard, of an oblong figure, and with us commonly about 3½ inches long and 2½ broad; on which are printed a variety of points and figures; a certain number or assemblage of which serve for the performance of various games, as ombre, picquet, whist, &c. A full pack consists of fifty-two cards. The inventor of cards is not known, nor even the age when they first appeared; but judging from the material they were originally made of, viz. leaves of paper, they appear to be prior to the time of Charlemagne. The Hon. Daines Barrington, Mr. Bowles, and Mr. Gough, in their three essays on the "*Antiquity of Card-playing*," seem to agree that the Spaniards have the best pretensions to be considered as the original inventors of this amusement. Others have traced their invention to about the year 1390, for the purpose of diverting Charles VI., then king of France, who had fallen into a deep melancholy, and ascribe it to Jaquemin Gringonneur, a painter in Paris. Accordingly, in the accounts of the treasurer of that prince, the following article occurs: "Paid fifty-six shillings of

Paris, to Jaquenin Gringonneur, the painter, for three packs of cards gilded with gold, and painted with divers colours and divers devices, to be carried to the king for his amusement." From this item of account it appears, that the playing cards were originally very different in their appearance and price from what they are at present. They were gilt, and the figures were painted or illuminated, which required no little skill and genius, as well as labour. This last circumstance is one reason that playing cards were little known and used for several years after they were invented. By the four suits or colours, the inventor might design to represent the four states or classes of men in the kingdom. The *coeurs*, or hearts, denote the *gens de choeur*, choir-men or ecclesiastics. The nobility or principal military part of the kingdom is represented by the ends or points of lances or pikes, which, through ignorance of the meaning of the figure, we have called spades. By diamonds are designated the order of citizens, merchants, and tradesmen. The trefoil leaf, or clover grass, incorrectly called clubs, alludes to the husbandmen and peasants. The four kings are David, Alexander, Cæsar, and Charles, representing the four celebrated monarchs of the Jews, Greeks, Romans, and Franks, under Charlemagne. The queens represent Argine (for regina, queen by descent), Esther, Judith, and Pallas; which are typical of birth, piety, fortitude, and wisdom. The knaves denote the servants to the knights. The first certain notice of their having been known in England occurs in a record in the time or Edward IV. On an application of the card-makers of London to Parliament, A. D. 1463, an act was made against the importation of playing cards. From this statute it appears, that both card-playing and card-making were known and practised in England before this period, or about 50 years after the era of their supposed invention. Mr. Gough observes, that the use of cards among the Chinese is evident, not only from a Chinese painting, which represents their ladies playing at a game with something much thicker in substance than cards, yet shaped and numbered like them, but also from a pack of Chinese cards in his possession, made of the same materials as the European. However, the devices on the cards are very different from those known in this part of the world.

Careening (in French, *faire abattre, carèner*); heaving the vessel down on one side, by applying a strong purchase to the masts, so that the vessel may be cleansed from any filth which adheres to it by careening.

A *half careen* takes place when it is not possible to come at the bottom of the ship; so that only half of it can be careened.

Caribbee Bark. Under the general denomination of *cinchona*, several barks have been comprehended which are not the products of the real cinchona, and which, in fact, neither contain cinchona nor quinia, and cannot, consequently, be substituted as a febrifuge for the true species of cinchona. One of the principal substitutes of this kind is the Caribbee or St. Lucia bark, which is procured from the *exostema Caribæa* (Persoon), a tree growing in the West Indies. This bark is in convex fragments, covered with a yellow epidermis, commonly thin, but sometimes hard and spongy, with deep fissures, of a yellow, red, or brown tint internally, of a fibrous texture, offering here and there small shining and crystalline points of a very bitter taste and very faint smell.

Carminative, in *Medicine*; a denomination formerly applied to those articles of the materia medica which possess the property of dispelling wind from the stomach.

Carmine, the most splendid of all the red colours, is made from the cochineal insect, or *coccus cacti*. It is deposited from a decoction of powdered cochineal in water, to which alum, carbonate of soda, or oxide of tin, is added. As the beauty of this valuable colour is affected not only by the mode of applying it, but also by the quantity of the ingredients mixed with it, we find various recipes for the preparation of it. The manufactories which prepare the best carmine carefully conceal the method. The best natural cochineal is found in Mexico.

Carnation, in the *Fine Arts*; the colouring of the flesh of the human body. The use of carnation requires very attentive study and great skill in the artist. It varies with the sex of the individual, with the classes and countries to which the subjects belong, with the passions, the state of the health, &c. The cheeks are, in a healthy subject, of a lively red; the breast, neck, and upper part of the arms of a soft white; the belly yellowish. At the extremities the colour becomes colder, and at the joints assumes a violet tint, on account of the transparent appearance of the blood. All these shades require to be softly blended. Two faults in carnation are chiefly to be avoided—hardness, the fault of the masters of the 15th century, and too great weakness. Guido Reni not unfrequently painted his flesh so that it appeared almost bloodless. The French school has gone farthest in this respect. The flesh of the followers of this school often looks like porcelain or wax. Titian is still unrivalled in carnation.

Carotid, in *Anatomy*; a name given to the large arteries which supply the head, from a mistaken notion that tying these vessels would induce sleep.—There are two common carotid arteries, a right and left; of which the former is a arch of the arteria innominata, the latter arises from the branch of the aorta. Each of these vessels are again divided into an external and internal carotid artery.

Carpenter; an artificer in wood.

Carpentry; the art of employing timber in the construction of edifices. See Wood and Timber, manufactures connected with.

Carpets are thick textures, composed wholly or partly of wool, and wrought by several dissimilar methods. The simplest mode is that used in weaving Venetian carpets, the texture of which is plain, composed of a striped woollen warp on a thick woof of linen thread.

Kidderminster carpeting is composed of two woollen webs, which intersect each other in such a manner as to produce definite figures.

Brussels carpeting has a basis composed of a warp and woof of strong linen thread. But to every two threads of linen in the warp, there is added a parcel of about ten threads of woollen of different colours. The linen thread never appears on the upper surface, but parts of the woollen threads are from time to time drawn up in loops, so as to constitute ornamental figures, the proper colour being each time selected from the parcel to which it belongs. A sufficient number of these loops is raised to produce an uniform surface. To render them equal, each row passes

over a wire, which is subsequently withdrawn. In some cases the loops are cut through with the end of the wire, which is sharpened for the purpose, so as to cut off the thread as it passes out. In forming the figure, the weaver is guided by a pattern which is drawn in squares upon paper.

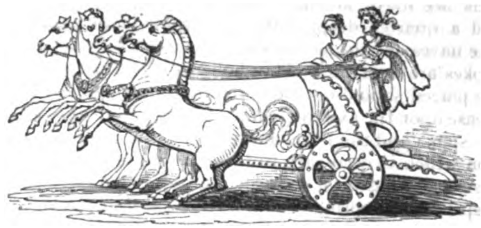
Turkey carpets appear to be fabricated upon the same general principles as the Brussels, except that the texture is all woollen, and the loops larger, and always cut. The English and Americans are the only nations among whom carpets are articles of general use.

CARRIAGE. The employment of wheel carriages may be traced to a very early period, and their usefulness principally arises from their power of diminishing friction. This important desideratum is effected by changing the rubbing motion of a sledge into the rolling motion of a cylinder. Thus wheels were probably at first but rollers. Whether their application to the removal of timber and heavy loads was accidental, or the invention of some early mechanic, is now but of little consequence to determine.

To improve these embryo germs of mechanism, and bring them into the form of wheels supporting a load upon an axletree, required a considerable degree of ingenuity; they must at first have been solid, the axletree must have been originally made of wood, and was probably fixed in the wheels, and moved round under the shafts or body of the carriage, as is common at present in the Irish car. The use of iron gudgeons, or iron axletrees, could not have been common in the first stages of civilization, and the separation of the wheels from the axletree was therefore of later date. Yet in the earliest authentic history which exists, chariots are mentioned as in use for pleasure, for war, and for carrying burthens.

Whilst carriages were used, where no regular roads had been made, the mechanical advantages of high and low wheels were not of consequence; the safety of the driver was the principal object. The height of the wheels was determined by the convenience of the warrior, and they were made of such a height as to permit him, encumbered with his armour, to ascend and descend with facility. We accordingly find in all ancient gems and monuments, that from the earliest antiquity the ancient war chariot had low wheels, the front part of the chariot high, to protect the warrior, the hinder part low and open, to permit him to mount and to descend easily; the pole was attached to the yoke that lay on the horse's withers, without any harness, but a collar round his neck, and two straps to hold it on. A metal chariot of a similar construction was dug up at Rome about the beginning of the present century.

As warriors generally employed more horses than were required for their weight and that of the car which bore them, there was no necessity for inquiry into the best form and size of wheels, or of any nicety in the means by which the horses were attached to the carriage. We read of no carriage drawn by one horse only, two horses were usually employed. In Homer, the chariots of Achilles and of other warriors appear to be drawn by two horses; but in some ancient gems it appears that chariots were drawn by four, six, and eight horses; and on one beautiful gem, in honour of a victor at the Olympic games, the chariot is drawn by twelve horses abreast. An engraved representation of an ancient carriage with horses will best illustrate their general form.



In coaches, and all other four-wheeled carriages, the fore-wheels are made of a less size than the hind ones, both on account of turning short, and to avoid cutting the braces: otherwise the carriage would go much easier if the fore-wheels were as high as the hind ones; and the higher the better, because they would sink to less depths in the small hollows in the roads, and be the more easily drawn out of them. But carriers and coachmen give another reason for making the fore-wheels much lower than the hind-wheels; namely, that when they are so, the hind-wheels help to push on the fore ones: which is, however, too unphilosophical and absurd to deserve a refutation.

In the preceding observations, we have supposed the rims of the wheels to be cylindrical. In concave wheels, however, the rims are uniformly made of a conical form, which not only increases the disadvantages that we have ascribed to them, but adds many more to the number. Mr. Cumming, in a valuable treatise on wheel carriages, solely devoted to the consideration of this single point, has shown, with great ability, the disadvantages of conical rims, and the propriety of making them cylindrical; but we are of opinion that he has ascribed to conical rims several disadvantages which arise chiefly from an inclination of the spokes. He insists much upon the injury done to the roads by the use of conical rims; yet, though we are convinced that they are more injurious to pavements and highways than cylindrical rims, we are equally convinced that this injury is occasioned chiefly by the oblique pressure of the inclined spokes. The defects of conical rims are so numerous and palpable, that it is wonderful how they should have been so long overlooked. Every cone that is put in motion upon a plane surface, will revolve round its vertex, and if force is employed to confine it to a straight line, the smaller parts of the cone will be dragged along the ground, and the friction greatly increased. Now when a cart moves upon conical wheels, one part of the cone rolls while the other is dragged along, and though confined to a rectilineal direction by external force, their natural tendency to revolve round their vertex occasions a great and continued friction upon the linchpin, the shoulder of the axletree, and the sides of deep ruts.

As the rims of wheels wear soonest at their edges, they should be made thinner in the middle, and ought to be fastened to the fellies with nails of such a kind, that their heads may not rise above the surface of the rim. In some military waggons, we have seen the heads of these nails rising an inch above the rims, which not only destroys the pavements of streets, but opposes a continual resistance to the motion of the wheel. If these wheels were eight in number, the wheel would experience the same resistance as if

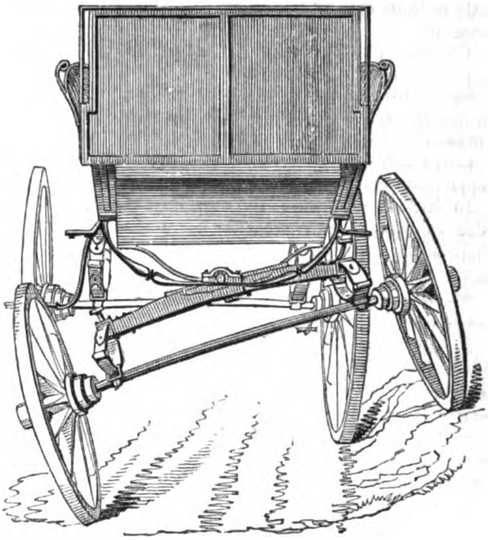
it had to surmount eight obstacles, one inch high, during every revolution. The fellies on which the rims are fixed, should in carriages be three inches and a quarter deep, and in waggons four inches. The naves should be thickest at the place where the spokes are inserted, and the holes in which the spokes are placed should not be bored quite through, as the grease upon the axletree would insinuate itself between the spoke and the nave, and prevent that close adhesion which is necessary to the strength of the wheel.

A coach has been defined, "a convenient carriage suspended on springs, and moving on four wheels," intended originally for the conveyance of persons in the upper circles of society, but now become very common among the middling classes in almost all civilized countries. The fashions, with regard to the form and ornament of coaches and other carriages for pleasure, are perpetually changing; the chief kinds now in use are, the close coach and chariot, the landau, which can lower its roof and part of its sides, like the head of a phæton; the barouche, or open summer carriage, made on the lightest construction; the chariot, which is intended only for two or three persons; the landaulet, or chariot whose head unfolds back; in addition to which there is the britscha, a carriage now very generally employed. These all run upon four wheels. Of the two-wheeled vehicles, there is the curricle, drawn by two horses, each bearing on a narrow saddle the end of a sliding-bar or yoke that upholds a central pole; the gig, chaise, or wiskey, that have each only one horse, which moves between a pair of shafts, borne nearly horizontally, by means of a leathern sling passing over the saddle-tree. When a gig, &c., has two horses, one preceding the other, in harness, the machine and its horses are, taken together, denominated a tandem. In addition to these we have a tilbury, a cabriolet, and a Stanhope.

Mr. Fuller has effected a considerable improvement on light four-wheel carriages, which is deserving of notice. It consists in the adaptation of an apparatus to the front part of the vehicle, which is designed to prevent the carriage from overturning, by preserving the body at all times in a horizontal position, even when one of the wheels accidentally passes over a large stone in the road, or up a bank by the road side, or any other obstruction which would overthrow a carriage built upon any of the ordinary plans at present in use.

The principle of this invention will perhaps be best understood, by first pointing out the difficulty with which four-wheeled carriages are drawn over impediments, or uneven roads. Stage coaches are particularly subject to this disadvantage, as will appear upon a slight view of these vehicles, which are usually made as follows:—The body part being intended to bear the weight of fifteen persons with luggage, must be very securely framed together, and consequently cannot admit of the least flexibility. The carriage, therefore, in accommodating itself to the unevenness of the roads, must frequently run upon three wheels, and thereby be subjected to very considerable strain; for it is evident, that if one corner be raised by a wheel passing over a stone, or any other sudden rise in the road, that one half of the carriage will be raised at the same time, and the whole weight of that half so lifted will be supported by the elevated wheel, and its axle and springs at the corner, which passes over the obstacle; the spring being thereby greatly depressed. Each wheel, axle, and spring, therefore is occasionally required to support double the weight that they are designed to carry; and this being thrown upon them suddenly, renders it necessary to construct those parts of the carriage of double the strength that would otherwise be thought desirable.

The present invention is intended to remove this disadvantage, which will be better understood by an engraving.

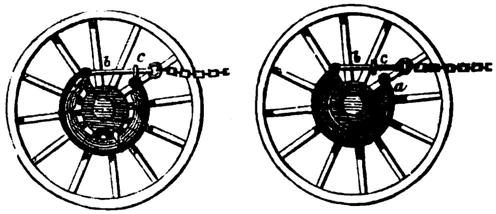


A circular horizontal locking-wheel, formed of iron, is attached to the front part of the carriage. This bears upon the axletree bed and upon segments supported by iron arms, and is enabled to turn round horizontally upon these bearings in the act of locking; the axletree bed itself being attached to, and supported by the front springs. A bar crosses the middle of the locking-wheel, and is attached to it by ears and bolts, the centre of this bar having a circular hole, through which a pin passes for the purpose of forming the pivot or axle on which the locking-wheel turns. The extremities of the bar, which extend beyond the wheel, are made truly cylindrical, and to these are attached the plummer-boxes, or gudgeons, from whence the bent arms extend for the purpose of supporting the front part of the body of the carriage, as seen in the figure.

It will now be perceived, that in the event of one of the fore-wheels running over a large stone, or any other elevated obstruction in the road, the axletree will be thrown out of its horizontal position; but the body of the carriage in front being supported solely upon the pivots at the ends of the bar, the plummer-boxes will turn upon the pivots, and cause the bent arms to keep the body of the carriage in its erect position, although one of the fore-wheels is raised up so considerably.

A very ingenious *drag* for vehicles descending hills has been contrived by Mr. Rapson, which is well worthy of notice. This drag is to be applied to the naves of the carriage wheels, with a chain attached, fastened to the breeching of the horse, and a small pin on each side of the shaft is to go into the bar of the drag. If one of these pins be taken out, the

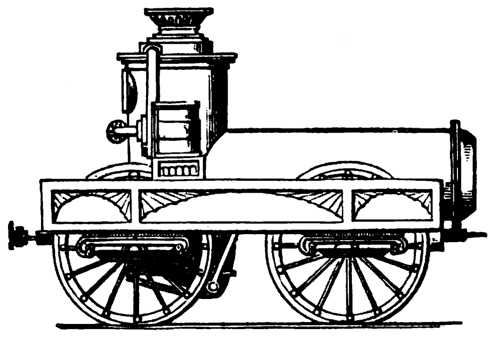
wheel will be dragged, but the other will of course turn freely; and by leaving out both pins, the wheels are acted upon in conjunction, during the descent, by the breech bearing against the horse.



In the first of these diagrams we have a representation of the break attached to the carriage, but inoperative; as it will be seen that the chain *c*, and bolt *b*, admit the jointed circle to remain at some distance from the nave of the wheel.

In the second figure, the entire frame, *a, b, c*, are seen in direct collision with the nave, and act by their friction to retard the wheel; this, however, does not occur till the breeching of the harness is drawn tight by the descent of the carriage on an inclined road.

We have now to notice a form of vehicle which under most circumstances seems likely to supersede those now in use. We need hardly add, that we allude to the carriage propelled by steam; an engraving of one of these vehicles, copied from Mr. Gordon's valuable treatise on locomotion, may be found interesting.



Dr. Darwin, in the spirit of prophecy, more than half a century back, predicted such an event. His words are—

> "Soon shall thine arm, unconquered steam, afar
> Drag the slow carriage, and impel the rapid car;
> Or on wide-waving wings expanded bear
> The flying chariot through the fields of air."

Now the steam-boat and steam-carriage have already been placed in practical operation; and Sir George Cayley, in a very ingenious paper in the *Philosophical Magazine*, furnishes data which show the aerial carriage to be any thing but wild or visionary.

Carriages of this description vary very considerably in their weight, from four or five tons, down to as many ounces. The Editor of this work has one which goes at the rate of nine miles per hour on a level road, and yet weighs less than one pound. He possesses another, which is under the entire controul of the conductor, carries two persons, and weighs less than one hundred weight; so that the enormous mass of iron now generally employed in these vehicles, may be reduced to a great extent. It may be proper to add, that a vehicle of this description is now exhibiting in London, weighing *five tons!* The possibility of their general employment on common roads has now ceased to be problematic; and there is no doubt but that we shall be enabled to congratulate our readers on their complete success, when describing their mechanical structure, under the article STEAM CARRIAGES.

CARRONADES (from the river *Carron*, in Scotland, where they were first made); a sort of artillery resembling howitzers. They are of very large caliber, and carry balls, shells, or cartouches. They are much lighter than common cannon, and have a chamber for the powder like mortars. They are mostly used on board of ships in close engagements, from the poop and forecastle. Sometimes they are employed in fortifications. They have been cast from 12 to 68 pounders. They were first used in the North American revolutionary war.

CART. See CARRIAGE.

CARTILAGE is a semi-pellucid substance, of a milk-white or pearly colour, entering into the composition of several parts of the body. It holds a middle rank, in point of firmness, between bones or hard parts, and the softer constituents of the human frame. It appears, on a superficial examination, to be homogeneous in its texture; for when cut, the surface is uniform, and contains no visible cells, cavities, nor pores, but resembles the section of a piece of glue. It possesses a very high degree of elasticity, which property distinguishes it from all other parts of the body. Hence it enters into the composition of parts whose functions require the combination of firmness with pliancy and flexibility, the preservation of a certain external form, with the power of yielding to external force or pressure. Anatomists divide cartilages into two kinds, the *temporary* and the *permanent*. The former are confined to the earlier stages of existence; the latter commonly retain their cartilaginous structure throughout life. The *temporary cartilages* are those in which the bones are formed. All the bones except the teeth are formed in a *nidus* of cartilage. The *permanent cartilages* are of various kinds. They compose the external ear and external aperture of the nostrils and eyelids. The larynx is formed entirely of this substance, and the trachea or windpipe, with its branches, is furnished with cartilaginous hoops, by which these tubes are kept permanently open for the ready passage of air to and from the lungs.

The bodies of the vertebræ are joined by large masses of a peculiar substance, partaking of the properties and appearance of cartilage and ligament, which allow of the motions of these parts on each other, without weakening the support that is afforded to the upper parts of the body in general, and to the head in particular, by the vertebral column. These cartilages impart great elasticity to the spine, by which the effects of concussion from jumping, from falls, &c., are weakened and destroyed before they can be propagated to the head. When the body has been long in an erect position, the compression of these cartilages, by the superior parts, diminishes the height of the person. They recover their former length when freed from this pressure. Hence a person is taller when he rises in the morning, than after sustaining the fatigues of the day, and the difference has sometimes amounted to an inch. Cartilages are

sometimes interposed between the articular surfaces of bones, where they fill up irregularities that might otherwise impede the motions of the part, and increase the security of the joint by adapting the articular surfaces to each other. These surfaces are in every instance covered by a thin crust of cartilage, having its surface most exquisitely polished, by which all friction in the motions of the joint is avoided.

CARTOON has many significations. In painting, it denotes a sketch on thick paper, pasteboard, or other material, which is used as a model for a large picture, especially in fresco, oil, tapestry, and formerly in glass and mosaic. In fresco painting, cartoons are particularly useful; because in this a quick process is necessary, and a fault cannot easily be corrected. In applying cartoons, the artist commonly traces them through, covering the back of the design with black lead or red chalk; then laying the picture on the wall or other matter, he passes lightly over each stroke of the design with a point, which leaves an impression of the colour on the plate or wall; or the outlines of the figures are pricked with a needle, and then the cartoon being placed against the wall, a bag of coal-dust is drawn over the holes, in order to transfer the outlines to the wall.

In fresco painting, the figures were formerly cut out, and fixed firmly on the moist plaster. The painter then traced their contour with a pencil of wood or iron; so that the outlines of the figures appeared on the fresh plaster, with a slight but distinct impression, when the cartoon was taken away. In the manufacture of a certain kind of tapestry, the figures are still cut out, and laid behind or under the woof, by which the artist directs his operations. In this case the cartoons must be coloured. Of this kind are the cartoons which Raphael executed for Pope Leo X., from which the famous tapestries of Raphael in the Netherlands were woven. There were twelve of them, representing histories taken from the New Testament. Seven of them are still extant, and may be seen at Hampton Court palace. Rubens bought these cartoons for Charles I., and King William built a gallery for them at Hampton Court. The cartoon of the School of Athens, carried to Paris by the French, and a fragment of the Battle of Maxentius and Constantine, are preserved in the Ambrosian Gallery at Milan. There are likewise cartoons by Giulio Romano in the Sala Borgia, by Domenichino and other Italian masters, who caused their pictures to be executed, in a great degree by their scholars, after these cartoons.

The value set upon cartoons by the old Italian masters may be seen by Giov. B. Armenini's *Precetti della Pittura*. In later times, large paintings, particularly in fresco, were not executed so frequently. The artists also laboured with less care, and formed their great works more from small sketches. In modern times, some German artists have prepared accurate cartoons. Among them is Cornelius, whose cartoons, for his fresco paintings in Münich, have acquired much celebrity. He prepared, too, a cartoon for the fresco picture representing *Joseph interpreting the Dream*. Overbeck also has made cartoons, from which he has painted the *Seven Years of Famine*, and the *Selling of Joseph*. The *Seven Years of Plenty* he executed, with the assistance of William Schadow and Philip Veit. The representations of Joseph's history, just mentioned, the late Prussian consul-general Bertholdy has caused to be executed in fresco, at his residence in Rome, by the above-named artists. For the villa Massimi, near Rome, Overbeck has prepared cartoons representing scenes from Tasso's *Jerusalem Delivered;* Julius Schnorr, illustrations of Ariosto, and Veit, scenes taken from Dante.

CARTOUCH, in *Architecture, Sculpture*, &c., denotes an ornament representing a scroll of paper, being usually in the form of a table, or flat member, with wavings, whereon is some inscription or device.

In Heraldry; a name given to a sort of oval shields, much used by the popes and secular princes in Italy, and others, both clergy and laity, for painting or engraving their arms on.

In the Military Art; a wooden case, about three inches thick at bottom, and girt round with marline, holding 2, 3, or 400 musket balls, with 8 or 10 iron balls, weighing one pound each, to be fired from a mortar, gun, or howitzer, for the defence of a pass, retrenchment, &c. It is also used for a cartridge-box, now employed mostly by the infantry. The charge of a cannon is also sometimes called by this name.

Cartouche is likewise the name given by the French literati to that oval ring or border which includes, in the Egyptian hieroglyphics, the names of persons of high distinction, as M. Champollion has proved. This border was thought at first, by Zoëga, to include every proper name.

CARTRIDGE; a case of paper, parchment, or flannel, fitted to the bore of fire-arms, and filled with gunpowder, to expedite the discharge of the piece. Cartridges are of two sorts, viz. *ball*-cartridges, used in firing balls, and *blank*-cartridges, used in firing without ball. Riflemen avoid the use of cartridges, because the cartridge injures the shot of a rifle. In most armies, a soldier carries 60 cartridges into battle.

CARVER; a cutter of figures or devices in wood.

CARYATIDES. See ARCHITECTURE.

CASE-HARDENING is a process by which iron is superficially converted into steel, in such articles as require the toughness of the former, conjointly with the hardness of the latter substance. The articles intended for case-hardening are first manufactured in iron, and are then placed in an iron box, with vegetable or animal coals in powder, to undergo cementation. Immersion of the heated pieces into water hardens the surface, which is afterwards polished. Coarse files and gun-barrels are among the articles most commonly case-hardened.

CASEMATES (from the Spanish *casa*, a house, and *matare*, to kill), in fortification; vaults which are proof against bombs, under the main wall, particularly in bastions, for the purpose of defending the moat of a fortification, also for making countermines. They serve at the same time as a place for keeping the heavy ordnance, and in case of necessity, as habitations for the garrison.

CASE-SHOT, in artillery, is formed by putting a quantity of small iron balls into a cylindrical tin box, called a *canister*, that just fits the bore of the gun. In case of necessity, the canister is filled with broken pieces of iron, nails, stones, &c. The case is closed at both ends by wood. Shot of this sort are thrown from cannons and howitzers. In sieges, sometimes, instead of cases, bags are used. This kind of shot is very injurious to the enemy, because

the balls contained in the canister spread, diverging in proportion to the distance. The amount of divergence is, to the distance which the shot reaches, generally in the proportion of 1 to 10; thus, at the distance of 600 paces, they make a circle of 60 paces diameter. The canisters used in the Prussian army contain balls of 1, 1½, 3, 4, 6, 8, and 12 ounces, and of 1 pound. The distance which the shot will reach varies according to the weight and number of the balls. A six-pounder shoots canister balls of 1 ounce from 200 to 500 paces; twelve and twenty-four-pounders shoot balls of 1 pound 800 to 1000 paces. The number of the balls varies according to their weight.

CASQUE; a defensive armour for covering the head and neck. The king had one gilt with gold; the dukes and counts had theirs with silver; gentlemen of high extraction wore theirs of polished steel, and the rest of plain iron. The Romans had their casques of brass or iron, which were proof against the strokes of any sword or sabre, and were ornamented to the height of two feet with plumes of feathers, or tufts of horse hair, of different colours. The chiefs and principal officers wore casques gilt and enriched with precious stones, with the tops of them ornamented with plumes and aigrettes of great value, which served to distinguish them from others. The Scandinavians, and other people of the North, used to wear them, and their invention is ascribed by some to the Scythians and the Celts.

CASSINO; a game at cards, in which four are dealt to each player, four being also placed on the board. The object is to take as many cards as possible, by making combinations. Thus, a ten in the player's hand will take a ten from the board, or any number of cards which can be made to combine into tens. The greatest number of cards reckons three points, and of spades, one; the ten of diamonds, two; the two of spades, one; and each of the aces, one.

CASSIOPEIA, in *Astronomy*, is a conspicuous constellation in the northern hemisphere, situated next to Cepheus. In 1572, a new and brilliant star appeared in it, which, however, after a short time gradually diminished, and at last disappeared entirely. It was thought at that time, by many persons, that this was the star which appeared to the wise men in the East. The constellation Cassiopeia contains 52 stars of the first six magnitudes.

CASTANETS; small wooden rattles, made in the shape of two bowls or cups, fitted together, and tied by a string, and then fastened to the thumbs. The fingers being rapidly struck upon them, a tremulous sound is produced, which marks exactly the measure of the dance. Something similar to this was the *crotalon* of the ancients, who also made use of small cymbals in their dances and festivals in honour of Bacchus. It is probable, however, that they had their origin in the East, and were brought by the Moors into Spain. Here, too, they received their name *castanuelas*, from being commonly made of the wood of the chestnut (*castano*), or from their colour. They are still in use in Spain, and here and there in the south of France. The charm of variety has also procured for them a place in ballets and operas, where they have now become general.

CAST ENGRAVINGS An important discovery has lately been made, which consists in taking moulds from every kind of engraving, whether line, mezzotinto, or aquatinta, and in pouring on this mould an alloy in a state of fusion, capable of taking, as it is stated, the finest impression. No sooner is one cast worn out, than another may immediately be procured from the original plate, so that every impression may be a proof. (See STEREOTYPE.)

CASTING. Iron, as well as brass, and other metals which melt at temperatures above ignition, is cast in moulds made of sand. The kind of sand most employed is loam, which possesses a sufficient portion of argillaceous matter to render it moderately cohesive when damp. The mould is formed by burying in the sand a wooden pattern, having exactly the shape of the article to be cast. The sand is most commonly enclosed in flasks, which are square wooden frames, resembling boxes, open at top and bottom. If the pattern be of such form that it can be lifted out of the sand without deranging the form of the mould, it is only necessary to make an impression of the pattern in one flask; and articles of this kind are sometimes cast in the open sand upon the floor of the foundry. But when the shape is such that the pattern could not be extracted without breaking the mould, two flasks are necessary, having half the mould formed in each. The first flask is filled with sand, by ramming it close, and is smoothed off at the top. The pattern is separated into halves, one half being imbedded in this flask. A quantity of white sand, or burned sand, is sprinkled over the surface, to prevent the two flasks from cohering. The second flask is then placed upon the top of the first, having pins to guide it; the other half of the pattern is put in its place, and the flask is filled with sand, which of course receives the impression of the remaining half of the pattern on its under side. After one or more holes are made in the top, to permit the metal to be poured in and the steam and air to escape, the flasks are separated and the pattern withdrawn. When the flasks are again united, a perfect cavity or mould is formed, into which the melted metal is poured. The arrangement of the mould is of course varied for different articles.

When the form of the article is complex and difficult, as in some hollow vessels, crooked pipes, &c., the pattern is made in three or more pieces, which are put together to form the mould, and afterwards taken apart to extract them. In some other irregular articles, one part is cast first, and afterwards inserted in the flask which is to form the other part. The metal for small articles is usually dipped up with iron ladles coated with clay, and poured into the moulds. In large articles, such as cannon, the mould is formed in a pit dug in the earth near the furnace, and the melted metal is conveyed to it in a continued stream, through a channel communicating with the bottom of the furnace.

Cannon-balls are sometimes cast in moulds made of iron, and to prevent the melted metal from adhering, the inside of the mould is covered with powder of black lead. Rollers for flattening iron are also cast in iron cases. This method is called *chill casting*, and has for its object the hardening of the surface of the metal by the sudden reduction of temperature, which takes place in consequence of the superior conducting power of the iron mould. These rollers are afterwards turned smooth in a powerful lathe, which has a slow motion, that the cutting tool may not become heated by the friction.

Casting in Plaster. Copies are most frequently taken, both from new models and from old statues,

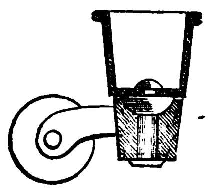
by casting them in plaster. For this purpose a mould in plaster is first made from the surface of the statue or figure itself; and this mould is afterwards used to reproduce the figure by casting. Plaster is prepared for use by pulverizing common gypsum, and exposing it to the heat of a fire until its moisture is wholly expelled. While in this dry state, if it be mixed with water to the consisience of cream or paste, it has the property of hardening in a few minutes, and takes a very sharp impression. The hardness afterwards increases by keeping, till it approaches the character of stone. Moulds are formed in the following manner:—The statue or figure to be copied is first oiled, to prevent it from cohering with the gypsum. A quantity of liquid plaster sufficient for the mould is then poured on immediately after being mixed, and suffered to harden. If the subject be a bass-relief, or any figure which can be withdrawn without injury, the mould may be considered as finished, requiring only to be surrounded with an edging. But if it be a statue, it cannot be withdrawn without breaking the mould; and on this account it becomes necessary to divide the mould into such a number of pieces as will separate perfectly from the original. These are taken off from the statue, and when afterwards replaced, or put together without the statue, they constitute a perfect mould. This mould, its parts having been oiled to prevent adhesion, is made to receive a quantity of plaster, by pouring it in at a small orifice. The mould is then turned in every direction in order that the plaster may fill every part of the surface; and when a sufficient quantity is poured in to produce the strength required in the cast, the remainder is often left hollow, for the sake of lightness and economy of the material. When the cast is dry, it is extricated by separating the pieces of the mould, and finished by removing the seams and blemishes with the proper tools. If the form or position require it, the limbs are cast separately, and afterwards cemented on.—Moulds and busts are obtained in a similar manner from living faces, by covering them with new plaster, and removing it afterwards as soon as it becomes hard. It is necessary that the skin of the face should be oiled; and during the operation the eyes are closed, and the person breathes through tubes inserted in the nostrils. Elastic moulds have been formed by pouring upon the figure to be copied a strong solution of glue. This hardens upon cooling, and takes a fine impression. It is then cut into suitable pieces, and removed. The advantage of the elastic mould is, that it separates more easily from irregular surfaces, or those with uneven projections and under-cuttings, from which a common mould could not be removed without violence. For small and delicate impressions in relief, melted sulphur is sometimes used; also a strong solution of isinglass in proof spirit.

Bronze Casting. Statues intended to occupy situations in which they may be exposed to violence, are commonly made of bronze. This material resists both mechanical injuries and decay from the influence of the atmosphere. The moulds in which bronze statues are cast are made on the pattern, out of plaster and brick-dust, the latter material being added to resist the heat of the melted metal. The parts of this mould are covered on their inside with a coating of clay, as thick as the bronze is intended to be. The mould is then closed and filled on its inside with a nucleus or core of plaster and brick-dust, mixed with water. When this is done, the mould is opened and the clay carefully removed.—The mould, with its core, is then thoroughly dried, and the core secured in its central position by short bars of bronze, which pass into it through the external part of the mould. The whole is then bound with iron hoops, and when placed in a proper situation for casting, the melted bronze is poured in through an aperture left for the purpose: of course the bronze fills the same cavity which was previously occupied by the clay, and forms a metallic covering to the core. This is afterwards made smooth by mechanical means.

Castor, the produce of the beaver. In the body of this animal are found four bags, a large and a small one, on each side; in the two large ones there is contained a softish, grayish, yellow, or light-brown substance, which, on exposure to the air, becomes dry and brittle, and of a brown colour. This is castor. It has a heavy but somewhat aromatic smell, not unlike musk; and a bitter, nauseous, and sub-acid taste. The best comes from Russia; but of late years it has been very scarce, and all that has been found in the shops is the produce of Canada. The goodness of castor is determined by its sensible qualities; that which is black is insipid, inodorous, oily, and unfit for use. Castor is said to be sometimes counterfeited by a mixture of some gummy and resinous substances; but the fraud is easily detected by comparing the smell and taste with those of real castor.

Castor; a friction-wheel placed beneath tables and other weighty articles of furniture to facilitate their removal. We notice the castor to point out a patent improvement of considerable importance by Mr. Geithner.

The improvement proposed is designed to give stability to the stem of the castor, and to enable it to turn upon its pin with less friction than those of the ordinary construction. This is effected by making the upper part of the vertical pin on which the socket of the roller carriage turns broad and partly spherical, which spherical part acts in a corresponding recess in the upper part of the socket of the roller carriage.



In the engraving is represented a section of the complete castor; at the top is the socket, into which the foot of the piece of furniture is inserted as usual; in this is placed the vertical pin riveted into the socket, upon which the carriage of the roller turns. The upper part of this pin, it will be seen, is enlarged and made in a convex form, which fits into the concave part of the stem of the roller carriage, and the pin and roller carriage being attached and secured by a nut or rivet, the carriage is enabled to turn round upon the pin with a very firm bearing, and with very little friction. The patentee does not confine himself precisely to this construction, but sometimes forms the convex part of the pin upwards, and causes it to act in a corresponding recess in the under part of the socket, which answers the purpose equally well.

Castor-Oil. The castor-oil plant (*ricinus palma Christi*) is a native both of the East and West Indies, and has a stem from 5 to 15 or 16 feet in height, and large, bluish-green leaves, divided into 7 lobes,

serrated and pointed, the foot-stalks long, and inserted into the disk. The flowers are produced in a terminating spike, and the seed-vessels are covered with spines, and contain three flattish, oblong seeds. it is to the seeds of this plant that we are indebted for the drug called *castor-oil*. It is now often prepared by pressing the seeds in the same way as is practised with oil of almonds. The oil thus obtained is called *cold expressed*. But the mode chiefly adopted in the West Indies is first to strip the seeds of their husks or pods, and then to bruise them in mortars. Afterwards they are tied in linen bags and boiled in water until the oil which they contain rises to the surface. This is carefully skimmed off, strained, to free it from any accidental impurities, and bottled for use. The oil which is obtained by boiling is considered more mild than that procured by pressure, but it sooner becomes rancid. The mildest and finest Jamaica castor-oil is very limpid, nearly colourless, and has scarcely more smell or taste than good olive-oil. Many people, however, have so great an aversion to castor-oil, even in its purest state, that they do not take it without great reluctance. The uses of castor-oil in medicine are well known; and it is exceedingly valuable as a mild and safe purgative. It is principally employed for children.

CASTRAMETATION; strictly, the art of tracing out and disposing to advantage the several parts of a camp on the ground. It is sometimes used more extensively to include all the ordinary operations of a campaign. A camp, whether composed of tents or barracks, or merely of places assigned for bivouacking, must be divided in such a way that the several divisions shall be disposed as they are intended to be when drawn up in order of battle; so that on a sudden alarm the troops may rise in their proper posts. At the same time the places for cooking, for the baggage, and for ammunition, must be conveniently arranged.

CASTRATION. See EMASCULATION.

CATACOUSTICS, called also *cataphonics*; the science of reflected sounds, or that part of acoustics which considers the properties of echoes.

CATALEPSY. This is a spasmodic disease, and by some regarded as a species of *tetanus*. It affects the whole body so as to render it immoveable, as if dead. *Tetanus* differs from *catalepsy* in its subjects and causes. Females are most liable to the last, while the first is equally produced in both sexes by appropriate causes. Tetanus is most frequently produced by punctured wounds of tendinous textures, and most readily in hot weather. Sometimes, however, it occurs like catalepsy, independently of wounds. The spasm is more limited in tetanus; sometimes being most severe in the muscles of the face, producing lock-jaw; now it attacks the muscles of the trunk on the fore part, producing *emprosthotonos*, and then the muscles of the back part, producing *opisthotonos*, or curvature of the trunk backwards. During all this the natural temperature may remain, the pulse be perfectly natural, and the senses unimpaired. Under the most active and varied treatment tetanus has always been a very fatal malady.

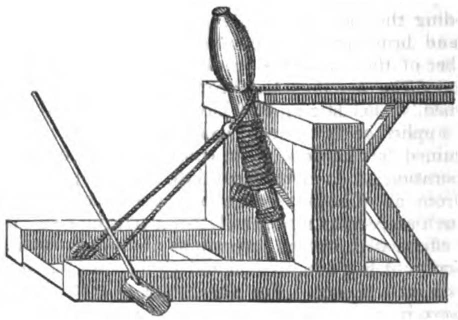
Catalepsy is an universal spasmedic disease of the organs of locomotion. The body remains in the position in which it may have been when attacked with the fit, and the limbs preserve any situation in which they may be placed. The senses are oblitерated, and the mind totally inactive, nothing being able to rouse the patient. The pulse and temperature remain natural. The fit is of uncertain length; according to some writers, not lasting more than a quarter of an hour, though known by others to be much longer. This disease is an obstinate one, and is very liable to recur, even when the patient seems in the least respect liable to a recurrence. It is, for the most part, a consequence of some other disease. This may be a local affection; but it more frequently occurs in a generally enfeebled constitution, induced by some dangerous malady, or one which has been caused by the gradual operation of unobserved morbid causes.

CATAMENIA. See MENSES.

CATAPELTA; an instrument of punishment in use among the ancients. It consisted of a press, composed of planks, between which the criminal was crushed to death.

CATAPLASMS, or POULTICES, are soft compounds, intended to be applied to the surface of the body.—They are commonly made of meal, boiled pulp, mixed with water, milk, or some other liquid. They are called *sinapisms* when mustard forms their base.

CATAPULTS; certain machines of the ancients, corresponding to our heavy cannon. The catapults differed from the *ballistæ* by throwing more horizontally, the latter more in a curve. The whole machine rested on a frame, and, if intended for the field, had wheels. The size of these machines varied much. The large catapults shot arrows of 3 cubits, or 4½ Roman feet, in length, often larger ones, and sometimes beams 12 feet long. Burning arrows were likewise often thrown by the catapults. The large ones threw their arrows 4 stadia, but not more than 2 stadia with precision. Pliny ascribes the invention of catapults to the Syrians; Plutarch and Diodorous, to other nations. A catapult of a very powerful kind is shown in the figure. From its structure it might be employed either for arrows or round stones.



At the siege of Jerusalem, the Romans had 300 catapults and 40 ballistæ. The Romans did not carry all the parts of these machines with them, but only the ropes and fastenings, with the necessary tools; and the soldiers built the catapults when they wanted them. The terms *catapult* and *ballistæ* were often used indiscriminately; and in later times, the word *catapult* went entirely out of use. Vegetius and Ammianus Marcellinus never introduce it, and employ *ballistæ* to signify all machines throwing large arrows or beams, and *onager* for those throwing stones.

CATARACT. By this term two very different dis-

cases are designated by some writers, viz., the true *cataract*, and *amaurosis*, or *gutta serena*. By the first of these terms, in its most common signification, is understood opacity of the crystalline lens, or its capsule, or both. By the second is meant a disease of the retina, by which it is rendered unsusceptible of the action of light. In cataract, the lens becomes opaque, loses its transparency, and is no longer capable of transmitting the light. The causes of cataract are numerous. Inflammation may produce it. Sometimes it is ascribed to a state of the vessels of the part which prevents a proper nourishment of the lens or its capsule. It is produced by various diseases, such as gout, rheumatism, scrofula, and accompanies old age. Its earliest approach is marked by a loss of the natural colour of the pupil; this becoming turbid, or slightly gray. *Muscæ volitantes* accompany this period. The opacity is not at first over the whole crystalline, and most frequently, first attacks the centre portion; this being turbid, and of a grayish colour, while the surrounding portions remain transparent, and of the usual black colour. While it exists in this degree only, the person can see in an oblique direction. The colour of the pupil is various; mostly grayish-white or pearl-coloured; sometimes milk-white, or of a yellowish-gray; now and then of a grayish-brown, and even of a dark-brown or dark-gray. The consistence of the lens differs in different cases, being either hard, and even horny, or very soft, as if dissolved.

The treatment of cataract is by a surgical operation on the eye, and different operations have been tried and recommended. They all consist in removing the diseased lens from its situation opposite the transparent cornea. By one of these operations the cataract is *depressed*, removed downwards, and kept from rising by the vitreous humour. This is called *couching*. Another operation is *extraction*, and consists in making an incision of the cornea, and of the capsule of the lens, by which the lens may be brought forward, and through the cut in the cornea. The third operation is by *absorption*. This consists in wounding the capsule, breaking down the crystalline, and bringing the fragments into the anterior chamber of the eye, where they are exposed to the action of the aqueous humour, and are at length absorbed. This last operation has the name *keratonyxis* applied to it. The choice of the operation is determined by the character of the cataract. After the operation, the patient is to be kept from the light, and from all means of irritation. Such medicines and such articles of food are to be prescribed as will most effectually prevent inflammation; and should this occur, it must be treated by such means as are the most sure to restrain or overcome it.

Amaurosis is a disease of the optic nerve, and its continuation, the retina. Its causes are numerous. It may be occasioned by organic disease of the parts referred to, by mechanical pressure upon the nerve, by too powerful light, by long-continued use of the eyes in too weak light, by rapid transition from darkness to light, and finally by old age. Various other, and some more general, causes may produce amaurosis. Among these are wounds of the head, compression of the brain, fits of apoplexy, suppressed colds in the head, habitual inebriety, vomiting, coughing, sneezing, affections of the alimentary canal, and some of the neighbouring viscera—the liver, for example. According to the activity of these various causes, the malady comes on suddenly or gradually. The patients are sometimes unable to bear the light, and therefore seek the darkness, where sparks and flames frequently appear to their eyes. Objects sometimes appear of different colours, or fluctuate, swim, and confuse themselves. At other times, the patients begin to squint, suffer a severe pain in the ball of the eye, and a straining above the eyebrows: finally, they begin to see as if through a crape or fog, and only in bright daylight can distinguish accurately: black flakes and specks appear to hover before their eyes. The greatest insensibility of the retina is often opposite the centre of the cornea; but ultimately the disease produces total blindness, the pupil losing its motion, and becoming permanently dilated. Deep in the eye a white speck is often visible, which is traversed by veins. According to the different causes, the malady is either easily cured or is incurable. Regard is especially to be had to them in the selection and use of remedies.

CATARRH; an increased secretion of mucus from the membranes of the nose, fauces, and bronchia, accompanied with fever, and attended with sneezing, cough, thirst, lassitude, and want of appetite. There are two species of catarrh, viz., *catarrhus à frigore*, which is very common, and is called a *cold in the head*; and *catarrhus à contagio*, the influenza, or epidemic catarrh, which sometimes attacks a whole city. Catarrh is also symptomatic of several other diseases. It is seldom fatal, except in scrofulous habits, by laying the foundation of phthisis; or where it is aggravated, by improper treatment, or repeated exposure to cold, into some degree of peripneumony; when there is hazard of the patient, particularly if advanced in life, being suffocated by the copious effusion of viscid matter into the air-passages. The epidemic is generally, but not invariably, more severe than the common form of the disease. The latter is usually left to subside spontaneously, which will commonly happen in a few days, by observing the antiphlogistic regimen. If there should be fixed pain of the chest, with any hardness of the pulse, a little blood may be taken from the arm, or topically, followed by a blister; the bowels must be kept regular, and diaphoretics employed, with demulcents and mild opiates, to quiet the cough. When the disease hangs about the patient in a chronic form, gentle tonics and expectorants are required, as myrrh, squill, &c. In the epidemic catarrh, more active evacuations are often required, the lungs being more seriously affected; but, though these should be promptly employed, they must not be carried too far, the disease being apt to assume the typhoid character in its progress; and, as the chief danger appears to be that suffocation may happen from the cause above mentioned, it is especially important to promote expectoration, first by antimonials, afterwards by squill, the inhalation of steam, &c., not neglecting to support the strength of the patient as the disease advances.

CATECHU; a brown astringent substance, formerly known by the name of *terra Japonica*, because supposed to be a kind of earth. It is, however, a vegetable substance, obtained from two plants; viz., the *mimosa*, or more correctly the *acacia catechu*, and the *ungaria gambir*. The first of these is a tree of from 20 to 30 feet high, found in abundance in many of the forests of India, from 16° of lat. up to 30°. The places most remarkable for its production, are

the Burman territories, a large province on the Malabar coast, called the Concan; and the forests skirting the northern part of Bengal, under the hills which divide it from Nepaul. The catechu is obtained from this tree by the simple process of boiling the heart of the wood for a few hours, when it assumes the look and consistency of tar. The substance hardens by cooling; is formed into small balls or squares; and being dried in the sun, is fit for the market. The price to the first purchaser in the Concan, is about 15*s.* a cwt. According to Dr. Davy, who analyzed it, the specific gravity of Concan catechu is 1.39; and that of Pegu 1.28. The taste of this substance is astringent, leaving behind a sensation of sweetness; it is almost wholly soluble in water. Of all the astringent substances we know, catechu appears to contain the largest portion of tannin. According to Mr. Rorkis, 1lb. is equivalent to 7 or 8lb. of our bark for tanning leather. From 200 grains of Concan concha, Dr. Davy procured 109 of tannin, 68 of extractive matter, 13 of mucilage, and 10 of earths and other impurities. The same quantity of Pegu catechu afforded 97 grains of tannin, 73 of extract, 16 of mucilage, and 14 of impurities. The uncaria gambir is a scandent shrub, extensively cultivated in all the countries lying on both sides of the straits of Malacca; but chiefly in the small islands at their eastern extremity. The catechu is in this case obtained by boiling the leaves, and inspissating the juice; a small quantity of crude sago being added to give the mass consistency; it is then dried in the sun, and being cut like the Concan catechu into small squares, is ready for use. There is a great consumption of this article throughout all parts of India, as a masticatory; it forms an ingredient in the compound of betel-pepper, areca-nut, and lime, which is in almost universal use. Catechu may be purchased at the Dutch settlement of Rhio, or at Malacca, in the straits of Singapore, at the rate of about 10*s.* a cwt. The quantity of it under the corrupted name of cutch, imported yearly into Calcutta from Pegu, at an average, at the five years ending with 1828-29, was about 300 tons, at a cost not exceeding 9*s.* per cwt. From Bombay a considerable quantity is annually imported into China. The quantity of catechu, under the name of gambir, produced in Rhio by the Chinese settlers, is equal to about 4,600 tons a year, about 2,000 of which are exported for the consumption of Java, the rest being sent to China, Cochin-China, and other neighbouring countries.

Catgut. The strings of certain musical instruments, the cords of clock-weights, and those of some other machines and implements, are made of a dense strong animal substance, denominated *catgut.* It is made from the intestines of different quadrupeds, particularly those of cattle and sheep. The manufacture is chiefly carried on in Italy and France. The texture from which it is made is that which anatomists call the *muscular coat,* which is carefully separated from the peritoneal and mucous membranes. After a tedious and troublesome process of steeping, scouring, fermenting, inflating, &c., the material is twisted, rubbed with horse-hair cords, fumigated with burning sulphur, to improve its colour, and dried. Cords of different size and strength, and delicacy, are obtained from different domestic animals. The intestine is sometimes cut into uniform strips, with an instrument made for the purpose. To prevent offensive effluvia during the process, and to get rid of the oily matter, the French make use of an alkaline liquid called *eau de Javelle.* Catgut for stringed instruments, as violins and harps, is made principally in Rome and Naples. For the smallest violin strings, three thicknesses are used; for the largest seven; and for the largest bass-viol strings, 120. In the kingdom of Naples, whence the best strings, commonly called *Roman,* are obtained, there are large manufactories of this article.

Cat-Harpings; small ropes in a ship, running in little blocks from one side of the shrouds to the other, near the deck. Their use is to force the main shrouds tight, for the ease and safety of the masts when the ship rolls.

Catoptrics; the science which treats of reflected light. It is a very important branch of optics, and will require particular notice. To render the subject intelligible, it will be necessary to take a brief view of the nature of reflecting bodies.

Any substance of a regular form, employed for the purpose of reflecting light, or of forming images of objects, is called a *speculum* or *mirror.* It is generally made of metal or glass, having a highly polished surface. The name of mirror is commonly given to reflectors that are made of glass; and the glass is always quicksilvered on the back, to make it reflect more light. The word *speculum* is used to describe a reflector which is metallic, such as those made of silver, steel, or of grain-tin mixed with copper.

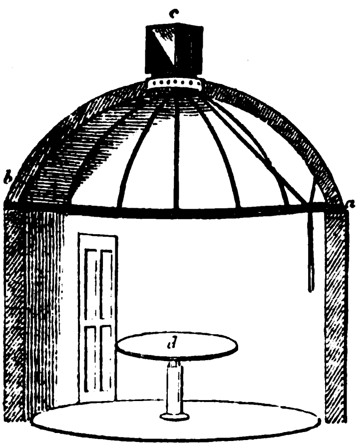
Specula or mirrors, are either *plane, concave,* o *convex.*

A *plane speculum* is one which is perfectly flat, like a looking-glass; a *concave speculum* is one which is hollow, like the inside of a watch-glass; and a *convex speculum* is one which is round, like the outside of a watch-glass.

As the light which falls upon glass mirrors is intercepted by the glass before it is reflected from the quicksilvered surface, we shall suppose all our mirrors to be formed of polished metal, as they are in almost all optical instruments. The image of any object is a picture of it formed either in the air, or in the bottom of the eye, or upon a white ground, such as a sheet of paper. Images are generally formed by mirrors or lenses, and accurately resemble the object in shape and colour; though they may be formed also by placing a screen, with a small aperture, between the object and the sheet of paper which is to receive the image.

Having thus illustrated the principal phenomena of reflection, we may now take two examples of its practical application in catoptrical instruments. The camera obscura, or dark chamber, is the name of an amusing and useful optical instrument, invented by the celebrated Baptista Porta. In its original state, it is nothing more than a dark room with an opening in the window-shutter, in which is placed a convex lens of one or more feet focal length. If a sheet of white paper is held perpendicularly behind the lens, and passing through its focus, there will be painted upon it an accurate picture of all the objects seen from the window, in which the trees and clouds will appear to move in the wind, and all living objects to display the same movements and gestures which they exhibit to the eye. The perfect resemblance of this picture to nature astonishes and delights every person, however often they may have seen it. The

image is of course inverted, but if we look over the top of the paper, it will be seen as if it were erect. The ground, *d*, on which the picture is received should be hollow, and part of a sphere whose radius is the focal distance of the convex lens. It is customary, therefore, to make it of the whitest plaster of Paris, with as smooth and accurate a surface as possible. In order to exhibit the picture to several spectators at once, and to enable any person to copy it, it is desirable that the image should be formed upon a horizontal table. This may be done by means of a metallic mirror, *c*, placed at an angle of 45°, the top revolving at *a b*, which will reflect the picture upon the white ground lying horizontally; an example of this kind, of the most improved construction, is given in the accompanying diagram.



In the more simple form of the instrument it is reflected upwards by the mirror, and received on the lower side of a plate of ground glass, with its rough side uppermost, upon which the picture may be copied with a fine sharp-pointed pencil.

All objects seen by reflection in a cylindrical mirror are necessarily distorted. If an observer looks into such a mirror, with its axis standing vertically, he will see the image of his head of the same length as the original, because the surface of the mirror is a straight line in a vertical direction. The breadth of the face will be greatly contracted in a horizontal direction, because the surface is very convex in that direction, and in intermediate directions, the head

will have intermediate breadths. If the axis of the mirror be held horizontally, the face will be as broad as life, but exceedingly short. If a picture or portrait, *c d*, is laid down before a mirror, *a b*, the reflected image will be highly distorted; but the picture may be drawn distorted according to regular laws, so that its image shall have the most correct proportions.

Cylindrical mirrors, similar to that represented above, which are now very uncommon, used to be made use of for this purpose, and were accompanied with a series of distorted figures, which, when seen by the eye, have neither shape nor meaning, but when laid down before a cylindrical mirror, the reflected image of them has the most perfect proportions.

CAT'S-EYE. See ASTERIA and QUARTZ.

CATSUP. See KETCHUP.

CAULKING, or CAUKING, of a ship, consists in driving a quantity of oakum, or old ropes untwisted and drawn asunder, into the seams of the planks, or into the intervals where the planks are joined together in the ship's decks or sides, in order to prevent the entrance of water. After the oakum is driven very hard into these seams, it is covered with hot melted pitch or resin, to keep the water from rotting it. Among the ancients, the first who made use of caulking were the inhabitants of Phœnicia, now Corfu. Wax and resin appear to have been commonly used previously to that period. The Poles use a sort of unctuous clay for the same purpose on their navigable rivers.

CAUSTIC. The name of *caustic* is given to substances which by their chemical action disorganize the parts of the body with which they are put in contact. They are called, likewise, *potential cauteries*, to distinguish them from the fire called *actual cautery*. Caustics, in general, act by decomposing chemically the tissues to which they are applied, by depriving them of life, and producing a real, local, and circumscribed gangrene, called *eschar*, or *slough*. Those, the action of which is powerful—for instance, caustic potassa, concentrated sulphuric acid, &c.—produce these phenomena with such rapidity that inflammation takes place only after the formation of the *eschar;* whilst, on the contrary, inflammation is the immediate consequence of the less energetic caustics. In both cases suppuration occurs sooner or later, and separates the disorganized from the surrounding parts. Almost all the substances used as caustics have only a local action: some, however, are capable of being absorbed, and of exercising a deleterious action on the economy in general: arsenical preparations are an instance of it.

The employment of caustics is now confined to a small number of cases. The actual cautery and the knife are in general preferred to them. They are used principally in order to establish issues, particularly in cases in which it is necessary to produce a powerful derivation; to stop the progress of certain gangrenous affections, such as *anthrax;* to open certain indolent abcesses; to change the mode of vitality of the skin in some cancerous or herpetic ulcers; to destroy the excrescences of wounds or proud flesh; and, finally, to prevent the absorption of the virus deposited at the surface of poisoned wounds.

CAUSTIC POTASSA; impure hydrate of protoxide of potassium; caustic kali with lime; common caustic. This is seen in flat, irregular, brittle pieces, or in round sticks, like the nitrate of silver; of a grayish-white, sometimes reddish; of a savour extremely caustic, and a slight odour *sui generis*. This substance is extremely caustic; it decomposes quickly the parts

with which it is put in contact, and leaves on the skin a soft, grayish, *eschar*, which comes off slowly. Taken internally, it acts in the same way as all corrosive poisons; it has nevertheless been administered in very dilute solutions, as an antacid, diuretic, and lithontriptic. It has succeeded in the gravel, in nephritic colics, and other affections proceeding from superabundance of uric acid. It has been recommended, likewise, in the treatment of scrofula, and in some diseases of the skin, such as leprosy, &c.—This solution, even when very diluted, soon irritates the stomach, and brings on anorexia, which prevents it from being used for any length of time.

Caustic Soda; protoxide of sodium. Its physical properties are similar to those of potassa, and it may be used with advantage as a *succedaneum* when employed as a caustic. In fact, the sub-carbonate, which forms during its action on the skin, is not deliquescent, as that of potassa, and consequently is not subject to spread.

Cavalier, in fortification, is a work generally raised within the body of the place, 10 or 12 feet higher than the rest of the works. It is most commonly situated within the bastion, and made much in the same form. Sometimes the cavaliers are placed in the gorges, or on the middle of the curtain; they are then made in the form of a horse-shoe. Their use is to command all the adjacent works and surrounding country. They are seldom made except when a rising ground overlooks some of the works. In modern times it is considered that cavaliers in a bastion occupy too much room, render retrenchments impossible, and unless a ditch separates the cavalier from the parapet of the bastion, cause the grenades to fall upon the defenders of the latter; for which reasons it is considered best to put them on the curtains or behind the bastions.

Cavalry; one of the three great classes of troops, and a formidable power in the hands of a leader who knows how to employ it with effect. This requires a bold and active spirit, able to avail itself with quickness and decision of every opportunity. The efficacy of cavalry arises particularly from the moral impression which it produces on the enemy. This is greater in proportion to the size of the mass and the rapidity of its motion. Its adaptation to speedy movements is another great advantage, which enables a commander to avail himself immediately of a decisive moment when the enemy exposes a weak point, or when disorder appears in his ranks. It is a very important instrument in completing the defeat of an enemy, in disconcerting him by a sudden attack, or overthrowing him by a powerful shock. The use of cavalry is, it is true, oftentimes limited by the nature of the ground. In forests, in mountainous districts, on a marshy soil, &c., it is of but little avail in large bodies. In modern times cavalry has been led against entrenchments, but only to its own destruction. In some instances, too, the cavalry has been dismounted, and employed as infantry; which may on peculiar occasions be advisable, but, on the whole, is contrary to their nature and purpose, and if made a part of their duty, like other half measures, is usually disadvantageous. It is also unadvisable to keep large bodies of cavalry united during a campaign. They are to be collected in large masses only for particular objects. To keep them together the whole time would be troublesome, and their maintenance frequently attended with difficulty.

The unequal size of the horse, the very great diversity in his strength and breed, have at all times rendered it necessary to divide the cavalry into *light* and *heavy horse*. There is sometimes, also, an intermediate class. These different sorts are employed for different purposes. The heavy cavalry with defensive armour (cuirassiers), is more frequently employed in mass, where force is requisite; the lighter troops are used singly, and in small detachments, where swiftness and continued effort are required. Nevertheless, cuirassiers and dragoons, lancers and hussars, mounted riflemen and *chevaux legers*, must, in the main points, be equally exercised in the duties appertaining to cavalry, and must be able to fight in the line as well as singly. The use of cavalry is probably nearly as ancient as war itself; for in those countries where horses thrive most, and man may be said to live on horseback, he has always preferred to fight on horseback.

The Egyptians are said to have had cavalry before the time of Moses. The Israelites, when at war with their neighbours, often had to encounter cavalry, but were afraid to mount horses until the time of Solomon. The Greeks appear not to have introduced cavalry into their armies till the second Messenian war, and even after that time had comparatively few; but with them it was considered the most respectable class of troops, in which only the wealthy citizens served. The Persian cavalry, and at a later period the Macedonian, were much more numerous. The Romans learnt its use from Pyrrhus and the Carthaginians. At a later period the cavalry of the Gauls was particularly good. In the middle ages, the knights fought only on horseback, and disdained the foot-service. At this period, however, regular warfare was unknown, and was only gradually restored in the progress of time. After the introduction of artillery, although cavalry was used, yet its manoeuvres were awkward and inefficient. The genius of Gustavus Adolphus first perceived the important use which could be made of it. He was without the heavy cavalry, which, since the time of chivalry, had gone out of use; but he found that the advantage of this species of troops did not consist in its weight, but in its quickness of motion. With reference to this, he formed his regiments of horse, and showed their real utility; but it was left to Seidlitz, a general of Frederic the Great, to display this most fully. Napoleon appears to have been well aware of the great value of cavalry in large masses, but he often sacrificed them unsparingly. This, together with certain erroneous dispositions which had crept into some armies, and had caused the cavalry to fail in services on which they ought never to have been put, and which were sometimes performed as well or better by other troops, gave rise, of late years, to doubts concerning their utility, which, however, are now abandoned. *(Statements and Observations respecting the Conduct and Fate of the Cavalry in the Campaigns of Frederic II., and in those of a later Period.)* In the north of Europe, lances are now common among the light cavalry, as they have proved a formidable weapon when skilfully used. They will no doubt, effect a change in the arms, and even in the organization of the infantry, who can do little against lancers, if rain prevents them from firing. In the Prussian cavalry, which is among the finest in the world, lancers are very numerous. A French author calls the cavalry, very appropriately, *l'arme du mo-*

ment; because they are peculiarly fitted to take advantage of decisive moments. A moment may occur, when a great victory can be decided by the sudden irruption of a body of cavalry, and the next moment it may be too late. A commander of cavalry must therefore be possessed of the rare courage which shrinks not from responsibility. Many battles in the late wars prove the truth of these remarks. Napoleon won the battle of Marengo chiefly by Kellermann's daring charge, at the head of 500 horse, on an enemy almost sure of victory. The campaigns in Russia, and the following war in Germany, showed the great disadvantage under which an army labours from the want of cavalry. Napoleon failed to follow up his advantages after the victories of Lützen and Dresden, chiefly because his cavalry were raw and inexperienced. The training of cavalry is much slower than that of infantry. The best cavalry is now generally considered to be the Prussian, and some species of the British. The French never were good horsemen, and the English have hardly kept pace with the numerous improvements introduced by the wars on the continent. It is a fact of interest, that the more civilization takes root among a nation, the more importance is given to infantry. All savage nations begin with cavalry, if they have horses. At present, infantry is the most numerous class of troops, though before the time of Charles V. they were little esteemed.

Caviare; the spawn or roe of sturgeon: it is either salted, dried, and made into small cakes, or is in its natural state packed up in kegs. It is in great repute in Russia, on account of the three seasons of Lent in that country. The sturgeon is found in the mouth of most of the rivers of Russia, particularly those which fall into the Caspian Sea. The sturgeon at the mouth of the Wolga, near Astrachan, is of a very large size.

Cavatina; a short air without a return or second part, and which is sometimes relieved with recitative.

Cayenne Pepper, or Capsicum. All the species of capsicum possess the same general qualities. In hot climates, but particularly in the East and West Indies, and some parts of Spanish America, the fruit of these plants is much used for culinary purposes. It is eaten in large quantities, both with animal and vegetable food, and is mixed in greater or less proportion with almost all kinds of sauces. The Cayenne pepper used in cookery is made from the fruit of different species of capsicum. This fruit, when ripe, is gathered, dried in the sun, and then pounded; and the powder is mixed with a certain portion of salt, and kept for use in closely-stopped bottles. It is very generally used as a poignant ingredient in soups and highly-seasoned dishes. Its taste is extremely acrid, and it leaves a durable sensation of heat on the palate, which is best removed by butter or oil. When taken in small quantities, Cayenne pepper is a grateful stimulant; and in medicine it is used both externally and internally, to promote the action of the bodily organs, when languid and torpid; and it is said to have been found efficacious in many gouty and paralytic cases. The Guinea pepper, or annual capsicum, is considered the most hardy of this whole tribe of plants; and in many parts of the south of Europe its fruit is eaten green by the peasants at their breakfasts, and is preferred by them to onions or garlic. The fruit of all the species may be used in domestic economy, either as a pickle, or when dried before a fire and ground to powder in a common pepper-mill, as Cayenne pepper.

Cell. This term is employed very frequently to signify any small compartment into which substances are divided; thus the hexagonal chambers of the honeycomb are called *cells*, as in botany the cavities separated by partitions in the pods, husks, or seed-vessels of plants, which are said to be *unilocular, bilocular, trilocular*, &c., according to the number of cells.

In anatomy, it is applied to various small cavities, such as the air-cells, or pulmonary vesicles, the adipose cells, or spaces in the membrane which retains the fat, &c. The loose, inflatable texture which unites and surrounds all the parts and organs of the body, has the name of *cellular*, from its being made up of a succession of these little interstices.

Cellular Substance, or Cellular Membrane (*tela cellulosa* or *mucosa* of Latin writers), is the medium which connects and supports all the various parts and structures of the body. Any person may gain a general notion of this substance by observing it in joints of veal, when it is inflated by the butchers. It consists of an assemblage of fibres and *laminæ* of animal matter, connected with each other so as to form innumerable cells or small cavities, from which its name of *cellular* is derived. It pervades every part of the animal structure. By joining together the minute fibrils of muscle, tendon, or nerve, it forms obvious and visible fibres. It collects these fibres into large *fasciculi*, and by joining such *fasciculi*, or bundles, to each other, constitutes an entire muscle, tendon, or nerve. It joins together the individual muscles, and is collected in their intervals. It surrounds each vessel and nerve in the body, often connecting these parts together by a firm kind of capsule, and in a looser form, joining them to the neighbouring muscles, &c. When condensed into a firm and compact structure, it constitutes the various membranes of the body, which, by long maceration in water, may be resolved into a loose cellular texture. In the bones it forms the basis or groundwork of their fabric, a receptacle, in the instertices of which the earth of bone is deposited.

As cellular substance is entirely soluble in boiling water, it is considered by chemists as that peculiar modification of animal matter termed *gelatine*. In consequence of its solution by the united agencies of heat and moisture, the muscular fibres separate from each other, and form the other structures of the body. This effect is seen in meat which is subjected to long boiling or stewing for the table, or, indeed, in a joint which is merely over-boiled. It forms a connection and passage between all parts of the body, however remote in situation or dissimilar in structure; for the cells of this substance every where communicate, as we may collect from facts of the most common and familiar occurrence. In emphysema, where air escapes from the lungs wounded by a broken rib into the cellular substance, it spreads rapidly from the chest into the most remote parts of the body, and has even been known to gain admission into the eye-ball. A similar diffusion of this fluid may be effected by artificial inflation.

Cements. The substances used for producing cohesion between different materials are very various. They are mostly, however, soft or semi-fluid, and harden in the course of time. The number employed is very great. We can mention only a few. The

joints of iron pipes, and the flanges of steam-engines, are cemented with a mixture composed of sulphur and muriate of ammonia, together with a large quantity of iron chippings. The putty of glaziers is a mixture of linseed oil and powdered chalk. Plaster of Paris, dried by heat, and mixed with water, or with rosin and wax, is used for uniting pieces of marble. A cement composed of brick-dust and rosin, or pitch, is employed by turners, and some other mechanics, to confine the material on which they are working. Common paint, made of white lead and oil, is used to cement China-ware. So also are resinous substances, such as mastic and shell lac, or isinglass dissolved in proof spirit or water. The paste of bookbinders and paper-hangers is made by boiling flour.

Rice-glue is made by boiling ground rice in soft water to the consistence of a thin jelly. Wafers are made of flour, isinglass, yeast, and white of eggs, dried in thin layers upon tin plates, and cut by a circular instrument. They are coloured by red-lead, &c.

Sealing-wax is composed of shell lac and rosin, and is commonly coloured with vermilion. Common glue is most usually employed for uniting wood, and similar porous substances. It does not answer for surfaces not porous, such as those of the metals, and is not durable if exposed to water.

The cements mostly used in building are composed of lime and sand. Lime is procured by burning substances in which it exists in combination with carbonic acid, such as limestone, marbles, chalk, and shells. By this process, the carbonic acid is driven off, and quicklime is obtained. The quicklime is slaked by mixture with water, after which it swells and cracks, becomes hot, and assumes the form of a white and impalpable powder. This is a hydrate of lime, and contains about three parts of lime to one of water. When intended for mortar, it should be immediately mixed with sand, and used without delay, before it imbibes carbonic acid anew from the atmosphere. The lime adheres to and unites the particles of the sand. Cements thus made increase in strength and solidity for an indefinite period. Fresh sand, wholly silicious and sharp, is the best. That taken from the sea-shore is unfit for making mortar, as the salt is apt to deliquesce and weaken the mortar. The amount of sand is always greater than that of the lime. From two to four parts of sand are used, according to the quality of the lime and the labour bestowed on it.

Water cements, called also *Roman cements*, harden under water, and consolidate almost immediately on being mixed. Common mortar dissolves or crumbles away, if laid under water before it has had time to harden; but certain rocks, which have an argillaceous as well as a silicious character, communicate to lime or mortar the property of hardening in a very few minutes, both in an out of water. The ancient Romans, in making their water cements, employed a peculiar earth, obtained at the town of Puteoli. This they called *pulvis Puteolanus*. It is the same that is now called *Puzzolana*. It is evidently of volcanic origin. The Dutch, in their great aquatic structures, have mostly employed a substance denominated *tarras, terras*, or *trass*, found near Andernach, in the vicinity of the Rhine. It is said to be a kind of decomposed basalt, but resembles Puzzolana. It is very durable in water, but inferior to the other kinds in the open air. Baked clay and the common greenstone afford the basis of very tolerable water cements, when mixed with lime. Some of the ores of manganese may be used for the same purpose. Some limestones, calcined and mixed with sand and water, also afford water cements, usually in consequence of containing some argillaceous earth.

Some cements, of great hardness and permanency, have been obtained from mixtures into which animal and vegetable substances enter, such as oil, milk, mucilage, &c. The name of *maltha* or *mastic* is given them. They are not much used.

The cement or plaster commonly used in France (which consists of a mixture of chalk, and strong size), is objectionable as being deficient in hardness, apt to chip or scale off, and unable to resist the rain. An ingenious experimentalist states, that a composition formed of slaked lime, mixed with 4 to 5-100 parts of alum, though dearer than the former, has been found preferable on account of its adhering more firmly to the wall, and better calculated to resist the inclemencies of the weather, which he conceives is owing to the alumine of the alum becoming incorporated with the lime. Following the advice of M. Dulong, he has endeavoured to imitate this cement on a more economical principle. To effect this, he has diluted slaked lime and white clay with water, and after mixing, suffered them to blend together and re-act upon each other for some time at an ordinary degree of temperature. The proportions of the separate ingredients are 100 parts of quicklime, five of white clay, and two of yellow-ochre. The process is as follows:

The lime is first slaked with a small quantity of water, more of which is added by degrees until the mixture is reduced to about the consistency of cream; the white clay is also diluted, and brought to a similar state, by being suffered to remain for some time in water, and the two solutions are then mixed carefully together.

The parts of walls covered with this cement, which have been exposed in the country, to the influence of the south-west winds, and rain, for the space of two years, have lost none of their colour, nor can any portion of the plaster be rubbed off by the hands.

Cementation; a chemical process, in which a metal (and often other bodies) is placed in connection with other substances, often in layers, in close vessels, that the former may be separated from its combinations, or changed (frequently oxydated), at a high temperature. The substance with which the metal or other body is surrounded is called *cement-powder*. In cementing gold, the alloy is beaten into thin plates, and placed in alternate layers, with a cement containing nitrate of potass and sulphate of iron. The whole is then exposed to heat until a great part of the alloying metals are removed by the action of the nitric acid liberated by the nitre. Iron is cemented with charcoal-powder and other substances, and thereby converted into steel. Glass is changed by cementation with gypsum, into Réaumur's porcelain. Copper is cemented with a powder of calamine and charcoal, and thereby converted into brass. The copper obtained from the sulphate of copper, by precipitation with iron, is called *cement copper*.

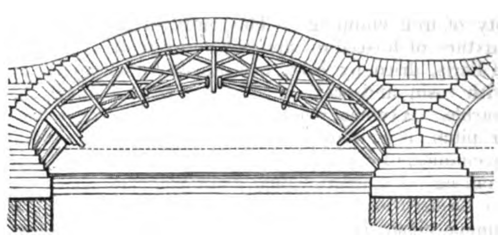
Cenotaph; a monument erected in honour of a deceased person, but not containing his body. Some of these monuments were erected in honour of per-

sons buried elsewhere, others for persons whose bodies were not interred. The ancients believe that, when the body was not buried, the soul could not be admitted into the abodes of the blessed. When a body could not be found, it was supposed that some rest was afforded to the sufferer by erecting him a cenotaph, and calling out his name three times with a loud voice. Such monuments were distinguished by a particular sign, usually a piece of a shipwrecked vessel, to denote the death of the deceased in a foreign land. The Pythagoreans erected cenotaphs to those who had quitted their sect, as if they were actually dead. We subjoin an example of a beautiful modern cenotaph, combining the purest principles of Greek sculpture with the most simple architectural adornments.

Centaur; a part of one of the old constellations. In Ptolemy's Catalogue the stars are 37 in number; and in the Britannic Catalogue 35. For an account of the comparative lustre of some of the stars in this combined constellation by Dr. Herschel, see the *Philosophical Transactions* for 1797, p. 314.

Centaury. There exist two plants of this name, used in medicine; *small centaury* and *American centaury*, extensively distributed throughout the United States. Both are esteemed as tonics and febrifuges: the latter, however, is preferred by the American physicians. It is also much used in domestic practice as a prophylactic against autumnal fevers, in strong infusions, in large and repeated doses.

Centering; in bridge building. A person unacquainted with the process by which the large curved vaults of masonry are erected for the arches of a bridge, might suppose some very complete mass of frame-work was required for the purpose; such however is not the case, as the centering merely consists of a series of timbers supported in the air, precisely in the same way as the stone-work is afterwards arranged. We give a view of the mode of effecting this in an arch of the largest span.



The first step in building a bridge is to prepare a coffer-dam, or water-tight chamber, by driving piles in the bed of the stream, and having pumped out the water from within, the piers are erected. If we now suppose them to be raised above the water line, the process of "centering" commences. The frame-work of which it is composed is elevated by a pair of high *shears*, like those used for placing a mast of a vessel in its seat. The arrangement of the bars in the centre will be readily seen by a reference to the figure; but the way by which it is afterwards removed will require a more particular notice.

It should be borne in mind, that when the arch is completed, it presses with enormous force on the wooden frame—with a force, indeed, equal to that of many hundred tons. Now to get over this apparently insurmountable difficulty in the way of their removal, the base of each line of timbers rests on a series of wedges, so that every blow of the hammer applied to the point of the wedge, tends to facilitate the removal of the centre, and in this way the enormous masses of stone, forming the arches of London Bridge, were brought into a state of equilibrium in mid-air, and afterwards left to support their own giant frame-work.

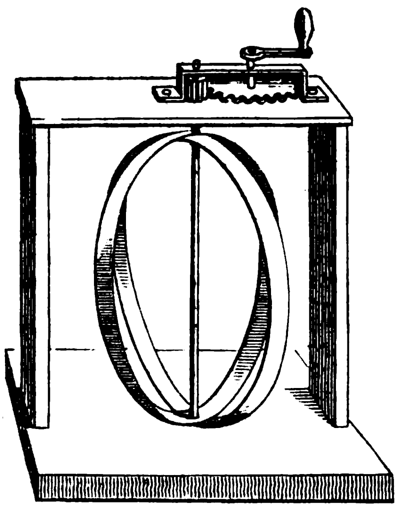
Centiare; a French measure, the hundredth part of an *are;* thus, also, according to the new French division of measures and weights, we have *centigramme, centilitre, centime, centimetre,* the hundredth part of a *gramme, litre, franc, metre.*

Central Fire. Many natural philosophers have supposed a perpetual fire to exist in the centre of the earth, which they call *central fire.* In ancient times, volcanoes and other similar phenomena were explained by it. At a later period, when it was understood that such a fire in the interior of the earth was impossible, the phrase was used to express the interior warmth of the earth. To this central warmth Mairan ascribes a great part of the warmth on the surface of the earth. To a certain depth there appears to be a fixed temperature in the interior of the earth, which probably arises from the penetrating heat of the sun. At least experiments show that in hot climates the interior of the earth is warmer than in cold ones. In Siberia, for instance, some workmen having penetrated 80 feet in digging a well, found the earth frozen even at that depth. Interesting information on this subject may be found in Biot's *Astronomie Physique.*

Central Forces; those forces by the co-operation of which circular motion is produced; that is, the centripetal and centrifugal forces. Many natural philosophers deny the existence of the latter, and assert it to be a mere mathematical idea. They say, a body once put in motion, continues its motion in the same direction, and with the same velocity, with-

out the interposition of a new power, on account of its *inertia*. Now, the heavenly bodies were impelled in the beginning by the Creator, with an almighty power, and would be obliged, by their *inertia*, to go on eternally in one direction, and with the same velocity, if they were not attracted, in all points of their motion, towards a point out of this direction, by which a circular motion is produced. Of the first moving force, there is now no longer any question. That power by which the heavenly bodies are drawn towards points out of their rectilinear path, is called the *centripetal force*. This power would put the heavenly body in motion if it were at rest; as it finds it already in motion, it changes its direction at every point. The case is quite different with the *centrifugal force*. This appears to be merely the result of the *inertia* of the body, or rather of the motion which, having been once given to the body, is continued by means of this *inertia*.

CENTRIFUGAL FORCE, in *Physics*, is the result of motion in any body made to revolve in a circle, which produces a tendency in the body to fly off from the centre of motion. One of the simplest modes of illustrating this effect, is to put water in a bucket, and if the experimentor whirl it round by a cord attached to the handle, no portion of the water will be spilt. The centrifugal force overcomes the gravitating force, and the fluid remains in the bucket.



A still more beautiful illustration may be given with the instrument represented above. Two elastic hoops being placed on one axis, are made to revolve by a multiplying wheel and handle, and as soon as motion is communicated they assume the form of an oblate spheroid. They expand at their equator, and are depressed at their poles. We give a figure of the instrument as it is found in the apparatus room of the London Institution, but by substituting a band for the toothed wheels, a more quiet and equable motion is produced.

Another mode of showing the same fact will be given under our article WHIRLING-TABLE, which is an instrument of considerable importance in central forces.

CENTRIPETAL FORCE. See CENTRAL FORCES.

CENTRO-LINEAD. See VANISHING POINT.

CENTURY (Latin *centuria*); a division of 100 men. This kind of division was very common with the Romans, and was used in general to denote a particular body, although this might not contain exactly 100 men. Thus, centuries in the army were the companies into which the Roman legions were divided.

CEPHALIC VEIN; one of the large superficial veins of the upper extremity.

CEPHEUS, in *Astronomy;* a constellation of the northern hemisphere, being one of the forty-eight old asterisms.

CERATE, in the materia medica; a kind of stiff unguent or liniment, made of oil and wax, with other ingredients; used externally in several diseases, especially those of the skin.

CERBERUS; a small northern constellation near Hercules.

CEREBELLUM, in *Anatomy;* that portion of the contents of the cranium which is contained in the lower fossæ of the occipital bone, and covered by the tentorium.

CEREBRUM, in *Anatomy*. This term in common language denotes the brain in general; but anatomists confine it to that part of the encephalon which occupies all the upper part of the cranium; indeed, by far the largest portion of the cavity.

CERES, in *Astronomy;* a new primary planet, discovered on the 1st of January, 1801, by the celebrated astronomer Piazzi. For a farther account of this planet, see ASTRONOMY.

CERINTHUS. See GNOSTICS and MILLENNIUM.

CERIUM, a rare metal, was discovered in 1803, by MM. Hisinger and Berzelius, in a Swedish mineral, known by the name of *cerite*. Dr. Thomson has since found it, to the extent of 34 per cent., in a mineral from Greenland, called *allanite*. The properties of cerium are in a great measure unknown. It is a brittle, white metal, which resists the action of nitric, but is dissolved by nitro-muriatic acid.

CERUSE, or white-lead, is an oxide of lead, saturated with carbonic acid, and is prepared as an article of commerce, by the action of acetic acid on the metal. Plates of lead being exposed to the vapours arising from boiling vinegar, are oxydised by the action of the air and the affinity of the acid. To obtain it in large quantities, plates of lead about 3 feet long, 6 inches broad, and 1 line thick, are rolled up in such a manner, that a space of half an inch or an inch is left between each roll. These rolls are fixed perpendicularly in earthen vessels which at the bottom contain strong vinegar. The latter, however, must not touch the plates; and, to prevent this, some little bars are placed over it in the form of a cross. The vessels are then covered with plates of lead, and being placed horizontally in tan or horse-dung, are exposed to a gentle heat. The vinegar now rises in vapours, which settle on the surfaces of the lead plates, penetrate them, and dissolve a great portion of the metal. In the space of from 3 to 6 weeks, the vapours of the acetic acid become saturated with lead, and change the latter into a whitish substance, which after some time is scraped off the plates, unrolled for this purpose. The plates are then rolled up again, and the same process is repeated. Ceruse is extensively used in the manufacture of oil paints, and, for this purpose, it is reduced to a fine powder. The pounding and bruising, however, are extremely injurious to the health.

The dust, if swallowed, causes a dangerous disease called the *painters' colic.*

CETUS, in *Astronomy* (the *Whale*); a large constellation of the southern hemisphere (being one of the forty-eight old asterisms) under Pisces, and next to Aquarius.

CHAIN, in surveying, is a measure consisting of a certain number of links of iron wire, serving to take the dimensions of fields, &c.

Chain, in nautical language. Chains are strong links or plates of iron, the lower ends of which are bolted through a ship's side to the timbers. They are also on the outside, and are used to contain the blocks called *dead-eyes,* by which the shrouds of the masts are extended. *Top chains* are those which preserve the lower yards from falling, when, in time of battle, the ropes are rendered incapable of service. Chains are now employed to a great extent for rigging.

CHAIN, GEARING. An ingenious and useful construction of gearing chain for connecting cog-wheels, has lately been invented by Mr. Oldham, engineer, of the Bank of Ireland, which we think highly deserving of the attention of machinists, as it is so extensively applicable to various kinds of machinery, such as carding engines; and indeed in almost every situation where a series of toothed wheels are required to be driven by one mover. It consists of a peculiarly constructed chain, with curved links, which when passed round a drum will serve as teeth, and act as a cog-wheel to turn pinions, &c.; and when stretched out straight, or placed on a flat surface, will form an endless rack. It may also be passed over and under a series of rollers, pinions, &c., forming a carrying-chain instead of the commonly constructed chains, in which spiked wheels are employed to take in the links.

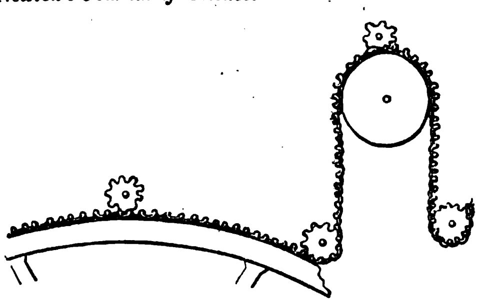
In carding engines, and various other kinds of machinery, this improved chain will work with much better effect in connection with pinions, or wheels with common teeth, into which it is suited to gear, than the old chains, and without the possibility of slipping off, or riding over the points of spiked wheels; having a broader surface of contact: and it is not at all liable to get out of order, being much stronger than the old linked chain used with spur pinions.

It is formed by crescent-shaped plates constituting links, which are connected together; and one and two plates alternately, or two and three, or more placed side by side; the alternate links fitting in between each other at the joints, where they are connected by pins, or bolts passed through their eyes in lateral directions.

It will be obvious that these curved links present on one surface of the chain semi-circular hollows like a rack, for the teeth of the pinions to take into, and that the ends of the links, where the bolts or rivets are passed through, are also formed semi-cirular, and the same size as the spaces or hollows of the links. These ends constitute teeth on the chain, and take into the spaces between the teeth of the pinions or wheels, and consequently drive them; or the chain itself may be driven by such pinions or wheels in the same way as a rack.

It is evident that such a chain may be passed in various directions over wheels, on its face, and over drums at its back, and may be used with certainty of effect: as whatever motion is given to the chain, will be communicated to all that is in gear with it.

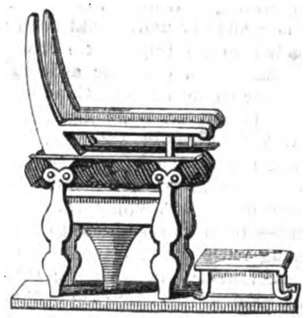
The accompanying engraving shows such a chain, supposed to be endless, carried over part of the periphery of a carding cylinder, and constituting a circular rack or toothed rim, which drives all the pinions connected to it; the back of the chain is conducted over a roller, and brought into gear with other pinions or wheels; but as numerous illustrations might be produced of its applicability, it is unnecessary to say more, as its adaptation to a very wide range of machinery will at once be perceived by every practical mechanic. For a farther account of this contrivance, and much useful information on similar subjects, see *Newton's Journal of Science.*



CHAIN-TIMBER; a timber of large dimensions, placed in the middle of a building, to give it strength.

CHAIR. The use of this valuable appendage to the domestic comfort of European nations is but little known in the warmer climates of the globe. Couches and mats are still employed over three-fourths of the earth.

The Etruscans were the first to use them generally, and yet strange to relate, the best form of our modern chairs scarcely exceeded those of Etrurian manufacture in point of beauty or convenience. An illustration of this fact will be found in the accompanying design, which is carefully copied from a bas-relief figure.



Etruria was at the height of its glory prior to the building of Rome, and yet the former people were more eminently skilled than their conquerors in all the arts which tend to the comfort and convenience of life. The chairs, as they are now constructed, are too well known to render any farther notice necessary; but our readers will find under the article BANQUET, in the SECOND DIVISION of this work, a graphic illustration of the species of couch formerly employed by the Romans, and still used in the East.

CHALK. See LIME.

CHAMADE, in military language (generally derived from the Italian *chiamare,* to call), is a signal, either by beat of drum or sound of trumpet, to obtain a

conference, when any matter is to be proposed to the enemy.

Chamber *of a Cannon*, in artillery; that part of the bore of a cannon which receives the powder with which it is charged.

Chamber of a mortar; the space where the powder lies.

Chamber of a mine; the place where the charge of powder is lodged that is to be used for blowing up the works.

Chamber of a battery; a place sunk under ground to hold the powder, bombs, &c., so as to preserve them from ruin or moisture.

Chamber of a lock is the space between the gates of a lock in a canal, in which the barge rises and sinks, so as to pass the lock. See Canal.

Chamomile, Roman; a perennial plant, native of Europe, and flowering in June or July. Chamomile flowers, such as they are found in the shops, are white, desiccated, of a very aromatic and rather pleasant smell, and of a very bitter and warm taste. They contain an essential oil of a fine blue colour, a gum-resinous principle, camphor, and tannin.—Water and alcohol dissolve their active principles. The Roman chamomile is a moderately energetic stimulant, possessing, on account of its bitterness, some tonic properties, which have rendered it a popular remedy for a number of diseases. It is employed with success to stimulate the digestive functions in dyspepsia, chlorosis, gout, in flatulent colics, &c. It is also advantageously used in slight intermittent fevers and spasmodic affections. A strong infusion, taken warm, and in a large quantity, provokes vomiting. The common chamomile is now out of use.

Champagne is a wine which is made chiefly in the department of the Marne, in the *ci-devant* province Champagne, and is commonly divided into river and mountain wines (*vins de la rivière de Marne*, and *vins de la montagne de Reims*); the former being, for the most part, white, the latter red. Not all of these wines are sparkling or frothing, though by the name *champagne* is generally understood such wine as has been subjected to an imperfect fermentation, and contains a quantity of carbonic acid gas, generated during the insensible fermentation in the bottle, which is disengaged on removing the pressure by which it was detained in solution. The briskest wines are not always the best; they are, of course, the most defective in true vinous quality; and the small portion of alcohol which they contain immediately escapes from the froth as it rises on the surface, carrying with it the aroma, and leaving the liquor that remains in the glass nearly vapid. For it has been shown, by Humboldt, that when the froth is collected under a bell-glass surrounded with ice, the alcohol becomes condensed on the sides of the vessel. Hence the still, or the creaming, or slightly sparkling Champagne wines (*vins crêmans*, or *demi-mousseux*) are more highly valued by connoisseurs, and fetch greater prices than the full-frothing wines (*vins grand mousseux*). By icing these wines before they are used, the tendency to effervesce is in some degree repressed; but when they are kept cool, this precaution is unnecessary. In general it may be observed, that the vineyards on the banks of the Marne supply the choicest wines, and that the quality degenerates in proportion as they recede from the river. Among the white wines of Champagne, the first rank is generally assigned to those of Sillery, the produce of the vineyards of Verzenay, Mailli, Raumont, &c. Of the Reims mountain wines, those of Verzi, Verzenay, Mailli, Bouzy, and St. Basle, are most esteemed; but the Clos St. Thierry furnishes perhaps the finest red champagne. The name *jolly champagne*, under which at present a large quantity of the best champagne is sold in the United States, does not originate from a place in Champagne, but from the owner of extensive vineyards in that province, who exports much champagne to the United States. The soil of the principal vineyards throughout Champagne is composed of a loose marl, resting on chalk, and sometimes mixed with flints. For the manufacture of the white champagne wines black grapes are now generally used. In making the red wines the grapes are trodden before they are introduced into the vat. Champagne, when well made, and placed in cool cellars, will retain its good qualities from 10 to 20 years. (For farther information respecting this delicious liquor, and the art of making it, see A. Henderson's *History of Ancient and Modern Wines*, London, 1824.

Champ-de-Bataille *(field of battle)*, in military language, is the ground on which an action is fought. The commander who obliges his adversary to quit this ground and abandon it to him, obtains the victory.

Chance is used to signify accident, and also probability. The latter is its meaning in mathematics. The doctrine of chances teaches how to find the probability of a given event taking place from an examination of the circumstances affecting it. It is called more properly by the French, *calcul des probabilités.* It is important for the calculation of insurance risks, the worth of life-annuities, &c. Pascal, Huygens, De Moivre, Parisot (*Traité du Calcul conjectural*, &c., Paris, 1810, 4to.), Laplace, Lacroix (*Traité élémentaire du Calcul des Probabilités*, Paris, 1816), and others, have written ably on this subject. James Bernouilli undertook a work *De Arte conjectandi*, but his death prevented its completion.

Chancel is that part of the choir of a church, between the altar or communion-table and the rail that encloses it, where the minister is placed at the celebration of the communion.

Channels, or Chain-Wales, of a ship; broad and thick planks projecting horizontally from the ship's outside, abreast of and somewhat behind the masts. They are formed to extend the shrouds from each other, and form the axis or middle line of the ship, so as to give greater security and support to the masts, as well as to prevent the shrouds from damaging the gunwale, or being injured by rubbing against it.

Chant. See Church Music.

Character. This name is given to certain marks used to signify objects or ideas. The ancient written language of the Chinese is a language of figures, every object or notion being expressed in it by a particular figure. We also, for the sake of brevity and precision, use in several sciences, certain signs: for instance—*Astronomical Signs:* ☉ Sun; ☽ Moon; ⊕ Earth; ☿ Mercury; ♀ Venus; ♂ Mars; ⚶ Vesta; ⚵ Juno; ⚴ Pallas; ⚳ Ceres; ♃ Jupiter; ♄ Saturn; ♅ Herschel. The twelve signs of the zodiac: ♈ Aries; ♉ Taurus; ♊ Gemini; ♋ Cancer; ♌ Leo; ♍ Virgo; ♎ Libra; ♏ Scorpio; ♐ Sagittarius; ♑ Capricornus; ♒ Aquarius; ♓ Pisces.—In *Algebra*, the first letters of the alphabet, *a, b, c*, commonly denote given magnitudes, while the last letters, *x, y,*

x, &c., stand for unknown magnitudes, which are to be found. Furthermore, + (*plus*) more, — (*minus*) less, signify addition and subtraction; × denotes multiplication, ÷ division, = equality, √ root (*radix*). Also: ° degree; ′ minute; ″ second; ‴ third; &c.—*Chemical Signs:* 🜁 air; 🜃 earth; ∇ water; △ fire; ☽ silver; ☉ gold; ♀ copper; ♂ iron; ♄ lead; ♃ tin; ☿ quicksilver; ⦶ nitre; ⊖ salt; 🜍 sulphur; 🜿 tartar.—*Geometrical and Trigonometrical Signs:* ∟ angle; △ triangle; □ square; ○ circle; ∽ similarity; ‖ or ‡‡ parallel; ≌ equality and similarity, or coincidence; A > B, A greater than B.—Formerly there were more signs and abbreviations used in scientific works than at present. In Prussia, the use of signs in medical prescriptions has been abolished on account of the danger of their being confounded.

Charcoal. For the various processes connected with the manufacture of charcoal, we must refer our readers to the article Carbon. In addition to which there are two facts of some importance, which have since come to hand. The first of these relates to the manufacture of charcoal on the large scale at Goersdorf, in Saxony. It having been suggested by M. Boult, that a superior charcoal might be produced by filling the interstices of the pile with small charcoal, the refuse of former burnings, an experiment was made, which, after being several times repeated, gave the following results; 1st, an increase of produce, amounting to not less than four per cent. above that yielded by the ordinary process; 2nd, a much smaller quantity of dust and small coal; 3rd, scarcely any smoke; 4th, charcoal of a very equal and superior quality.

A pile prepared for carbonization at Goersdorf contained in general about thirty *schragen* (318 cubic yards) of pine trees split in quarters, which yielded, including the small coal, from eighty-nine to ninety-two per cent. in bulk of charcoal. It was considered desirable to ascertain, whether by increasing the size of the pile, a more considerable product would be obtained. A pile containing forty-nine schragen (about 520 cubic yards), of cleft pine wood, gave in an experiment, during which the weather proved favourable, 89.94 per cent. of charcoal (including the small), very sonorous, and of very good quality. A second trial of 69½ schragen (740 cubic yards), of similar wood produced only 87.98 per cent., but the weather in this instance was unfavourable.

This experiment was repeated with seventy-one schragen (752 cubic yards), the weather continuing fine throughout the process; the produce amounted to 94.87 per cent.; equal in quality to the former results. The average results of the adoption of this process at Goersdorf, will appear from the following table of the produce, from the commencement to the date of the latest improvements:

	Produce per cent.		Total Produce per cent.
	Lagre.	Small.	
1821 . .	74.94	3.91	78.85
1822 . .	76.24	4.76	81.—
1823 . .	76.44	5.25	81.69
1824 . .	77.95	4.09	82.04
1825 . .	86.31	4.35	90.66
1826 . .	86.31	3.62	89.93
1827 . .	87.53	4.20	91.73

Another fact, and one of some importance is, that *turf* may, by the common process of carbonization, be converted into charcoal.

Chart. See Map.

Chasing, in *Sculpture;* the art of embossing on metals. This is the art of representing figures, &c., in a kind of *basso relievo*, punched out from behind, and sculptured on the front with small chisels and gravers.

Cheese; a preparation made from the curd of *milk*, which see. The curds are pressed in a mould by means of a strong screw, and all the whey extracted. The residuum forms the cheese of commerce. Its quality principally depends on whether cream, milk, or merely skimmed milk, has been employed in the formation of the curd. The county of Cheshire is said to produce the best cheese in this country, and the Swiss or Gruyere the best imported from abroad.

The immense quantities of cheese imported into this country will be best understood by reference to the parliamentary document which we subjoin:

	Cwt.	qrs.	lbs.
Total quantities imported in one year	189,892	0	12
Rates of duty charged	10*s*. 6*d*. per cent.		
Amount of duty received . . .	£98,668	0	0

Check; a draft or bill on a banking house, to be paid at sight, to the bearer.

Chemistry. In the present article we purpose giving a general history of the progress of chemistry, omitting only those portions, by some called its "golden age," when the dreams of the alchemist promised to open to mankind an inexhaustible supply of the precious metals. Of the amusing reveries of those philosophers, an account has already been given in our article on Alchemy; and the various details of chemical science will be found dispersed through the alphabetical arrangement of the work. By the term chemistry, the etymology of which is uncertain, we understand the science which teaches the nature of bodies, or rather the mutual agencies of the elements of which they are composed, with a view to determine the nature, proportions, and mode of combination of those elements in all bodies. *Natural philosophy*, or *physics*, examines the reciprocal influence of matter in masses. *Chemistry* treats of the mutual action of the integrant parts. In the former, the phenomena are produced by the general attraction or repulsion of bodies; in the latter, by minute combination or decomposition.

With our present knowledge of matter and its laws, we cannot separate physics entirely from chemistry: one science cannot be studied without the other. Those artisans who first discovered the means of melting, combining, and moulding the metals; those physicians who first extracted vegetable substances from plants, and observed their properties, were the first chemists. Instead, however, of observing a philosophical method in their examinations; instead of passing from what was known to what was unknown, early inquirers suffered themselves to be led astray by astrological dreams, the fables of the philosopher's stone, and a hundred other absurdities.

Until the year 1650, we find little worthy of notice in the history of chemistry. Rhazis, Roger Bacon, Arnaud de Villeneuve, Basilius Valentin, Paracelsus, Agricola, &c., observed some of the properties of

iron, quicksilver, antimony, ammoniac, saltpetre. They discovered sulphuric, nitric, and other acids; the mode of rectifying spirits, preparing opium, jalap, &c., and of purifying the alkalies. Glauber was distinguished for the accuracy of his observations. He endeavoured to improve certain instruments; advised operators not to throw away any residuum, in performing experiments, as useless; discovered the salt which is called, from him, *Glauber's salt*, &c. Such isolated discoveries, however, could not form a complete science. Stahl appeared, and although his theory was unsatisfactory and entirely gratuitous, and as later observations have proved, erroneous, yet he laid the foundations of a regular science. He was himself much indebted to the celebrated Becher, whose views he corrected and extended. He was sensible that the greater part of chemical phenomena might depend on a general cause, or at least on a few general principles, to which all combinations must necessarily be referred. He supposed that bodies contained a combustible element, which inflammable bodies lost by being burned, and which they could regain from other more inflammable bodies. This element he called *phlogiston*. The establishing of a hypothesis, which connected almost all phenomena with each other, was an important step. Boerhaave adopted Stahl's system, and contributed much to its general diffusion. He is the founder of philosophical chemistry, which he enriched with numerous experiments, in regard to fire, the caloric of light, &c. Although the principles on which those philosophers proceeded were false, yet the science was much advanced by their labours. It was reserved for Black, Priestley, Cavendish, and Lavoisier to overturn Stahl's system, and substitute the pneumatic or antiphlogistic chemistry, the best history of which is to be found in Fourcroy's *Philosophie Chimique*, and his *Système des Connaissances Chimiques*.

As soon as the composition of the atmospheric air was known, it was observed that combustible bodies, burning in contact with it, instead of losing one of their elements, absorbed one of the component parts of the air, and were thus increased in weight. This component part has received the name of *oxygen*, because many of the combustible bodies are changed by its absorption into acids. Oxygen now took the place of phlogiston, and explained the difficulties which beset the phlogistic theory. Light and unity were introduced into chemistry by the new technical nomenclature adopted in 1787, by the aid of which all the individual facts are easily retained in the memory, since the name of each body is expressive either of its composition or of its characteristic property. Twelve or fifteen terms have been found sufficient for creating a methodical language, in which there is no inexpressive term, and which, by changing the final syllables of certain names, indicates the change which takes place in the composition of the bodies. Lavoisier, Fourcroy, Guyton de Morveau, and Berthollet were the authors of this felicitous innovation. The chemical terminology admits of nothing arbitrary, and is adapted not only to express known phenomena, but also any which may be hereafter discovered. It is the first example of a systematic and analytic language.

The commencement of the 19th century forms a brilliant era in the progress of chemistry. The galvanic apparatus of Volta presented to the experimentor an agent unequalled in the variety, extent, and energy of its action upon common matter. With this apparatus, Sir Humphry Davy commenced a series of researches, which resulted in a greater modification of the science than it had ever before experienced. He proved that the fixed alkalies were compounds of oxygen with metallic bases, and thus led the way to the discovery of an analogous constitution in the alkaline earths. To the same individual the science is principally indebted for the establishment of the simple nature of chlorine, and for the investigation of iodine. His researches concerning the nature of flame, resulting as they did in the invention of the miner's safety-lamp, afforded to mankind a new demonstration of the utility of philosophy in contributing to the improvement of the arts of life.

But that department of chemistry which has of late been most successfully investigated, relates to the definite proportions in which bodies unite to form the various chemical compounds. To establish the conclusions which have been arrived at, a multitude of exact analyses were requisite. These were accomplished principally through the labours of Vauquelin, Gay-Lussac, Thénard, Berzelius, and Thompson: and have terminated in the establishment of the general truth that, when bodies combine chemically and intimately with each other, they combine in determinate quantities; and that when one body unites with another in more than one proportion, the ratio of the increase may be expressed by some simple multiple of the first proportion. Upon this general fact, Dr. Wollaston constructed the logametric scale of chemical equivalents—an invention which has contributed in an eminent degree to render our knowledge of the constitution of compounds precise, by introducing the sure basis of arithmetical relations, which, when fixed with accuracy, are not susceptible of change. The doctrine of definite proportionsmay therefore be regarded as having communicated to the principles of chemistry that certainty which has long been considered as peculiar to the mathematical sciences; and it is in the developement of these important relations that the advancement of the science has been most conspicuous.

Among the still more recent improvements in chemistry may be cited the discovery of Döbreiner, relating to the power of platinum in effecting the combination of oxygen and hydrogen; the researches of Faraday, in which many of the gases have been reduced to the liquid form; the discovery of new compounds of carbon and hydrogen, and the singular fact, which they exhibit, of different combinations being established in the same proportions; the elucidation of the new compounds of chlorine with carbon; of the peroxide of chlorine; the hydriodide of carbon; the perchloric, iodous, fulminic, and other acids; the discovery of the real bases of silex and zircon, and that of the new principle, brome: add to these, that our knowledge of light and electricity has been greatly enlarged, and that the phenomena of electro-magnetism are altogether new, and it becomes strikingly obvious that chemistry is still a progressive science. "Nor can any limits be placed to the extent of its investigations. Its analysis is indefinite; its termination will have been attained only when the real elements of bodies shall have been detected, and all their modifications traced: but how remote this may be from its present state we cannot judge. Nor can we, from our present knowledge,

form any just conception of the stages of discovery through which it has yet to pass."

Chemistry has two ways of becoming acquainted with the internal structure of bodies, *analysis* and *synthesis* (decomposition and combination). By the former, it separates the component parts of a compound body; by the latter, it combines the separated elements, so as to form anew the decomposed body, and to prove the correctness of the former process. These methods depend on a complete knowledge of the two powers by which all bodies in nature are set in motion, viz., *attraction* and *repulsion*. Attempts have been made to distinguish the attraction of elementary particles from planetary attraction; the former being designated as *chemical affinity:* but nature has only one kind of attraction. The alternate play of attraction and repulsion produces a great number of sensible phenomena, and a multitude of combinations, which change the nature and the properties of bodies. The study of these phenomena, and the knowledge of these combinations, appertain to the department of chemistry. The history of a body must always precede its analysis. The mere examination of its form, its colour, its weight, and the place where it was found, &c., is often sufficient, by a comparison, to lead to a knowledge of its chemical properties.

There is no science more extensive than chemistry, nor is it possible for one person to embrace it in its whole extent. To facilitate the study, it is considered in different points of view, and thrown into divisions and subdivisions, so that a person may devote himself to one department of it, although the method of observing, analyzing, and combining, is the same in all, and although all the phenomena must be explained by the general theory, and refer to certain laws, of which a previous knowledge is requisite. These laws constitute what is called *philosophical* chemistry, which explains what is meant by the affinity of aggregation or cohesion, and by the affinity of composition or chemical affinity. It treats of the phenomena of solution, saturation, crystallization, ebullition, fusion, neutralization. Chemical processes, by changing or modifying the properties of bodies, suggest to the observer important considerations on the changes of form, density, and temperature.

Philosophical chemistry weighs these considerations. It shows farther, that affinity may be exerted, 1. between two simple bodies; 2. between a simple and a compound one; 3. between compound bodies; and establishing the principle, that the same body has not the same affinity for all others, but attracts them unequally; it shows us the laws which determine this preference, and the circumstances which modify it; such as cohesion, mass, insolubility, elasticity, and temperature. It measures the degree of affinity, whether of simple or compound bodies. It observes the circumstances which aid or obstruct the play of attraction, and shows that two bodies will not act upon each other, unless one of them at least, is in a fluid state; that bodies even in a state of solution, act upon each other only at imperceptible distances; that two bodies, which have perceptible affinity, may be made to combine by the interposition of a third; and finally, that the peculiar properties of bodies are destroyed by their combination, and the compound possesses entirely new properties.

Proceeding from these principles to the examination of bodies themselves, philosophical chemistry considers the effects of light, heat, and electricity; the nature of the simple and compound inflammable bodies; of air and water; the composition and decomposition of acids; the nature and properties of the salts; their relations to the acids; the calcination, solution, and alloying of metals; the composition and nature of plants; the characteristics of the immediate elements of vegetable substances; the phenomena of animalization; the properties of animal compounds, and the decay of organic substances. This is the sphere of philosophical chemistry, while it confines itself to general views.

According to the application of these general views, chemistry is divided into seven or eight branches, which we have yet briefly to survey. The study of the great phenomena which are observed in the atmosphere, and which are called *meteors*, constitutes *meteorological* chemistry. This explains the formation of the clouds, rain, mist, snow, water-spouts; the state of the atmosphere in relation to the hygrometer, barometer, and thermometer; the nature of the aurora borealis, meteoric stones; in short, all the chemical processes going on above the surface of the earth. *Geological* chemistry treats principally of the great combinations of nature, which produce volcanoes, veins of metals, beds of mineral coal, basalt, mineral waters, the enormous masses of salt and lime, the saltpetre in the bed of the Indus, the natron of the lakes of Egypt, the borax of the lakes of Thibet. The geological chemist endeavours to discover and explain the causes of deluges, earthquakes, the decrease of the waters on the globe, the influence of climate on the colour of animals and plants, on the smell of flowers, and the taste of fruits. In these general views, he needs the aid of natural philosophy and physics. Chemistry, in its application to natural history, is divided in the same manner. There is a chemistry of the mineral kingdom, which comprises metallurgy and assaying, and the examination of all the inorganic substances, as stones, salts, metals, bitumen, waters; a chemistry of the vegetable kingdom, which analyzes plants and their immediate products; and a chemistry of the animal kingdom, which studies all substances derived from living or dead animals. This last is subdivided into *physiological* chemistry, which considers the changes produced in animal substances by the operation of life; *pathological* chemistry, which traces the changes produced by disease or organic defects; *therapeutic* or *pharmaceutic* chemistry, which teaches the nature and preparation of medicines, shows the means of preserving them, and exposes the pretensions of empirics; *hygietic* chemistry, which acquaints us with the means of constructing and arranging our habitations, so as to render them healthy, of examining the air which we must breathe in them, guarding against contagious diseases, choosing wholesome food, discovering the influence of occupation, fashion, and custom on the health.

Agricultural chemistry treats of the nature of plants and soils, and the laws of production. Sir Humphry Davy first gave it the character of a science. It treats, 1. of the general powers of matter which have any influence on vegetation, of gravity, cohesion, chemical affinity, heat, light, electricity, the elements of matter, especially such as are

found in vegetables, and the laws of their composition and arrangement; 2. of the organization of plants, their structure, the chemical composition of their organs, and the substances found in them, &c.; 3. of soils; 4. of the nature of manure.

Chemistry, finally, exerts an influence on the routine of domestic life, and on the arts. It simplifies and regulates the daily offices of the housekeeper; renders our dwellings healthy, warm, light; assists us in preparing clothing, food, drink, &c.: it teaches the best way of making bread; preparing and purifying oils; of constructing bake-houses, ovens, and hearths; of bleaching and washing all kinds of stuff; of producing artificial cold, &c. The application of chemistry to the arts and manufactures is, however, still more important and extensive. Here its aim is to discover, improve, extend, perfect and simplify the processes by which the objects to be prepared may be adapted to our wants. We close our remarks with the observation, that a knowledge of chemistry may frequently be useful in judicial proceedings, in exposing crime; in cases of poisoning, counterfeiting coins and written documents, &c.

Chemical Classification and Nomenclature. The chemist finds a small number of bodies, from which only one kind of matter can be obtained, in the present state of his knowledge, and by the instruments and agents which he now has at his disposal. On the other hand, there is a large number of bodies, from which he obtains several kinds of matter. The former he calls *elements*, or *simple bodies;* the latter, *compound bodies.* The number of simple bodies now known is scarcely more than fifty: that of the compounds is much greater, and might at first appear to be infinite, since not only a difference of elements, but even a difference of the proportions in which they are combined, makes an essential difference in the properties of the compound. It is, however, much less than would be supposed, and even less than the number of possible combinations of simple bodies. Twelve of the simple bodies are oxygen, iodine, chlorine, bromine, fluorine, hydrogen, boron, carbon, phosphorus, sulphur, azote, and selenium; and forty-one are metals. The five first are called *supporters of combustion,* because they combine with the others, producing a disengagement of heat and light, and *acidifying principles,* because they are also capable of producing acids by a similar combination. The others are called *simple combustibles,* because their union with the supporters of combustion, above mentioned, is a real combustion. Compound bodies, as has been observed, are not so numerous as might be supposed. They result, 1. from the combination of oxygen, or one of the other simple supporters of combustion, with one of the simple combustibles; such are the acids: 2. from that of a simple body combined with oxygen, with another similar compound; such are the salts: 3. from that of two, three, rarely four, simple combustibles with one another: 4. from that of oxygen with hydrogen and carbon, forming vegetable matter: 5. from that of oxygen with hydrogen, carbon and azote, forming animal matter.

Combustibles combined with the simple supporters of combustion are sometimes called *burned bodies;* from the number of their elements they are also called *binary compounds.* When their taste is acid, and they have the property of reddening vegetable blues, they are termed *acids.* If they are not acid to the taste, and have the property of turning blue what has been reddened by acids, they are distinguished by the termination *ide,* as *oxide, chloride,* &c. If only one of the latter class is formed, that is, if the supporter of combustion will unite with the combustible in only one proportion, we call this compound simply the *oxide, chloride,* &c., of the combustibles; as *oxide of carbon.* If they unite in several proportions, we call the first, or that which contains the smallest proportion of oxygen, &c., *protoxide,* &c., the second, *deutoxide;* the third, *tritoxide.* The highest is also called *peroxide.* So, if only one acid is formed, we designate it by the name of the combustible, with the termination *ic.* Thus carbon with oxygen forms *carbonic* acid. If several are formed, that which contains the larger proportion of the acidifying principle is designated by the termination *ic,* and that which contains less, by the termination *ous.* Thus sulphur forms *sulphuric* acid and *sulphurous* acid. If there are still intermediate compounds, we annex *hypo* (signifying *less*), to designate a lower degree of acidity. Thus we should have *sulphuric, hyposulphuric; sulphurous, hyposulphurous.* In the acids and oxides, chlorides, &c., the combustible is called the *base.* When the base is the same, the peroxide, &c., always contains less oxygen, &c. than the lowest acid. For the names of compounds of two binary burnt bodies, no rules have been adopted to express the union of two oxides, two acids, or an acid with a non-metallic oxide. But those formed of acids and metallic oxides are called *salts,* and their individual names are formed by changing the termination of the acid and placing it before the name of the metal; the termination *ous* is changed into *ite,* and *ic* into *ate;* sulphurous acid with the oxide of tin would form *sulphite of tin;* sulphuric acid and tin, *sulphate of tin.* If the same acid combines with more than one oxide of the same metal, then we prefix the characteristic of the oxide to the name of the acid; thus sulphuric acid, combined with the protoxide of iron, forms the *protosulphate,* with the peroxide, the *persulphate,* of iron. Other substances have also the property of uniting with acids, neutralizing them, and forming compounds analogous to salts. There are no general rules for the names of these compounds; but the substances themselves are called *salifiable bases.*

The rules of nomenclature, in regard to the combination of the combustibles, vary:—1. If the constituents are metals, they form *alloys.* 2. If the compounds are solid or liquid, and formed of a metallic and a non-metallic combustible, we give to the latter the termination *uret;* as, carbon with iron forms *carburet of iron.* If both are non-metallic, the termination *uret* may be attached to either; as, *phosphuret of sulphur,* or *sulphuret of phosphorous.* 3. If the compound is gaseous, we name the gas, or one of the gases if it is composed of two, and join the other component as an adjective; as, *phosphurated hydrogen.*

CHESS; the most celebrated and general of all sedentary games. One of the greatest charms of chess lies, no doubt, in the circumstance, that whilst man is everywhere surrounded by chance, in this game, as generally played, he has entirely excluded it, except that it must be decided by chance which of the two players shall begin. The game affords so much variety, so much scope for calculation, so many oppor-

tunities to exhibit foresight and penetration, that it has been held in great esteem by all nations acquainted with it, and all persons who have conquered the difficulties of learning it. The Mahommedans except chess from the law against gambling. Whilst this game affords enjoyment worthy of mature minds, it is an excellent exercise for the young, as it teaches patience and circumspection, strengthens the judgment, and encourages perseverance in a plan affording a prospect of eventual success, though at the moment the situation of things may appear very critical.— The Chinese pretend to have known it 200 years previous to our era. It was brought in the sixth century from India to Persia, whence it was spread by the Arabians and the crusaders all over the civilized world. It is most commonly used in Asia. In fact its whole composition and its name prove its Asiatic origin. In Sanscrit it is called *schthrantsh*, a word which is believed to indicate the most important component parts of an ancient Eastern army—elephants, infantry, baggage-waggons, and horses. But this name was supplanted by the Persian term *shah* (king); which the game has retained, more or less corrupted, in all languages. A proof of the great antiquity of the game of chess in this island will be found in the curious discovery which was made in Scotland in 1831. A number of ancient chess-men were found, which are now deposited in the British Museum. They are carved from the tusk of the walrus, and we give a view of the king, which is also curious, as a specimen of early art.

Generally, chess is played by two persons upon a board, the same as that used in draughts or chequers, containing 64 squares. The board must be so placed that each player has a white square at his right hand. The squares are named from the pieces, viz.: that on which the king is placed is called the *king's square;* that on which the king's pawn is placed, the *king's second square;* that before the pawn, the *king's third square;* the next, the *king's fourth;* and so on with all the pieces of each side. Each player has eight pieces and eight pawns. In placing the pieces, the ancient rule is to be followed—*servat regina colorem* (the queen maintains the colour)—that is, the black queen is to be placed on the black square in the middle of the line next to the player; in a similar way the white queen on the white field. On the side of the king and the queen stand the bishops; then follow the two knights; and last, the rooks or castles. The object of the game is to bring the adversary's king into such a situation that he cannot move, which is called *checkmating*. The king can never be taken. The play ends with a checkmate.—(It is related of Dr. Franklin, that once playing chess in Paris, and being checkmated, he said, "Take the king; I am a republican, and don't care for him.") It is not uninteresting to consider the different names which the pieces have received in various countries. In the East the queen is called by the more proper name of *vizier* or *general*.

The bishops are called in Germany *runners;* and in France *fools (fous)*. These were originally elephants, with giants on them. The knights are called in German *leapers*. The castles were originally *war-chariots*, which is also indicated by the word *rook*, from the Indian *roch* or *roth*. With the old Germans the pawns, now called *peasants*, were styled *Wenden* (Vandals), a tribe despised by the Germans. Don John of Austria had a room, the floor of which was made like a chess board. On this he played with living persons. The peasants of a German village, Stropke, or Strobeck, near Halberstadt, for about 300 years, have been distinguished as chess players. The reason for this is doubtful. The most probable opinion is, that a certain bishop who lived among them made them acquainted with this game, and freed them from several taxes on condition that they would continue to practice it.

Numerous anecdotes show how much the game of chess can absorb the mind. The Elector of Saxony, John Frederick, was taken prisoner in the battle at Mühlberg by the emperor Charles V., and was playing at chess with his fellow-prisoner, Ernest of Brunswick, when it was intimated to him that the emperor had sentenced him to death. He paused for a moment to remark on the irregularity of the proceeding, and immediately resumed the game, which he won, and expressed in a lively manner the pleasure which he derived from his victory. Charles XII. of Sweden played at chess when he was so closely besieged in the house near Bender, by the Turks. Al Amin, caliph of Bagdad, would not be disturbed in chess-playing when the city was carried by assault. Frederick the Great loved chess much. Napoleon did not play it particularly well.

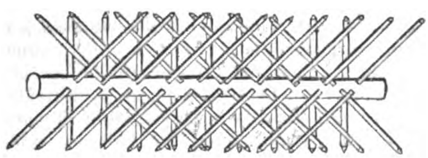
Among the most famous players and writers on the game are, a duke of Brunswick, named *Augustus*, who in the 17th century published, under the name of *Selenus*, an introduction to the game (1616, 4to.), now very rare; Philidor, a Frenchman, who was particularly distinguished in London in 1780—90; Gioacchino Greco, celebrated in the beginning of the 17th century; and the Arabian Philip Stamma in Paris, 1737. Caxton's "*Game and Playe of the Chesse*," printed in 1474, is generally admitted to be the first typographical work executed in England.—*Anastasia*, a German novel by Heynse, contains many ingenious ideas on chess-playing, and several fine games. Some very curious manuscripts relating to this game, in the Chinese, Sanscrit, Persian, and Arabic languages have been partially translated; and the presses of Europe have teemed with similar productions, the most noted of which are enumerated by Mr. Lewis, in the preface to his edition of *Saratt on Chess*, 1822.

Laws of the game.—1. If the board, or pieces, be

improperly placed, the mistake cannot be rectified after four moves on each side are played. 2. When a player has touched a piece, he must move it, unless it was only to replace it; when he must say, *J'adoube*, or *I replace*. 3. When a player has quitted a piece, he cannot recal the move. 4. If a player touch one of his adversary's pieces without saying *J'adoube*, he may be compelled to take it, or, if it cannot be taken, to move his king. 5. When a pawn is moved two steps, it may be taken by any adversary's pawn which it passes, and the capturing pawn must be placed in that square over which the other leaps. 6. The king cannot castle if he has before moved, if he is in *check*, if in castling he passes a check, or if the rook has moved. 7. Whenever a player *checks* his adversary's king, he must say *Check*, otherwise the adversary need not notice the check. If the player should on the next move attack the queen, or any other piece, and then say *Check*, his adversary may replace his last move, and defend his king. 8. When a pawn reaches the first row of the adversary's side, it may be made a queen, or any other piece the player chooses. 9. If a false move is made, and is not discovered until the next move is completed, it cannot be recalled. 10. The king cannot be moved into check, nor within one square of the adverse king, nor can any player move a piece or pawn that leaves his king in check.

Chest (called, in anatomical language, the *thorax*) is the cavity of the body between the neck and the belly. The external parts of the thorax are the skin, the breasts, various muscles, and the bones which form the frame of the cavity. These are the sternum, running from the neck down the middle of the breast, and the ribs, which are inserted in the spine, and arched towards the sternum, with which they are firmly connected by means of a cartilage. The parts within the cavity of the thorax are the pleura and its productions, the lungs, heart, thymus gland, œsophagus, thoracic duct, arch of the aorta, part of the vena cava, the vena azygos, the eighth pair of nerves, and part of the great intercostal nerve.

Chevaux de Frise (*Friesland horses*, so called because first used at the siege of Groningen, in that province, in 1658); an armed beam of square timber or iron, used to defend the fronts of camps, breaches, &c. They are usually from 15 to 18 feet long, and connected by chains, each being perforated with small holes, to receive rods of wood or iron, pointed at their extremities, and when moved in any direction, affording a sort of hedge of spears. An arrangement of this kind is shown in the accompanying engraving.



Chiaro Scuro (an Italian phrase, meaning *clear-obscure*; in French, *clair-obscur*), in *Painting*, is the art of judiciously distributing the lights and shadows in a picture. A composition, however perfect in other respects, becomes a picture only by means of the *chiaro scuro*, which gives faithfulness to the representation, and therefore is of the highest importance for the painter; at the same time, it is one of the most difficult branches of an artist's study, because of the want of precise rules for its execution. Every art has a point where rules fail, and genius only can direct. This point in the art of painting is the *chiaro scuro*. The drawing of a piece may be perfectly correct, the colouring may be brilliant and true, and yet the whole picture remain cold and hard. This we find often the case with the ancient painters before Raphael; and it is one of the great merits of this sublime artist, that he left his masters far behind him in *chiaro scuro*, though he is considered not so perfect in this branch as Correggio and Titian, who were inferior to him in many other respects. The mode in which the light and shade are distributed on any single object is easily shown by lines supposed to be drawn from the source of the light which is shed over the figure; but *chiaro scuro* comprehends besides this, aerial perspective, and the proportional force of colours, by which objects are made to advance or recede from the eye, produce a mutual effect, and form a united and beautiful whole.

Chiaro scuro requires great delicacy of conception and skill of execution; and excellence in this branch of art is to be attained only by the study of nature and of the best masters. *Chiaro scuro* is also understood in another sense, paintings in *chiaro scuro* being such as are painted in light and shade and reflexes only, without any other colour than the local one of the object, as representations of sculpture in stone or marble. There are some fine pieces of this sort in the Vatican at Rome, by Polidoro da Caravaggio, and on the walls of the staircase of the Royal Academy of London, by Cipriani and Rigaud.

Chilblains are painful inflammatory swellings, of a deep purple or leaden colour, to which the fingers, toes, heels, and other extreme parts of the body are subject on being exposed to a severe degree of cold. The pain is not constant, but rather pungent and shooting at particular times, and an insupportable itching attends it. In some instances, the skin remains entire; but in others, it breaks and discharges a thin fluid. When the degree of cold has been very great, or the application long continued, the parts affected are apt to mortify, and slough off, leaving a foul, ill-conditioned ulcer behind. Children and old people are more apt to be troubled with chilblains than persons of middle age; and such as are of a scrofulous habit are remarked to suffer severely from them.

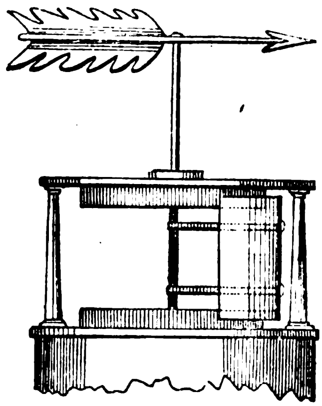
Chimes, in horology, is a species of music, mechanically produced by the strokes of hammers against a series of bells, tuned agreeably to a given scale in music. The hammers are lifted by levers, acted upon by metallic pins, or wooden pegs, stuck into a large barrel, which is made to revolve by clock-work, and is so connected with the striking part of the clock mechanism, that it is set in motion by it at certain intervals of time, usually every hour, or every quarter of an hour. The music thus produced may consist of a direct succession of the notes constituting an octave frequently repeated, or otherwise may be a psalm tune, or short popular air in the key to which the bells are tuned. This species of mechanical music most probably had its origin, like clock-work itself, in some of the monastic institutions of Germany, in the middle ages. The first apparatus for producing it is said to have been made at Alost, in the Netherlands, in 1487. The chime mechanism may be adapted to act with the large bells of a church

steeple by means of wheel-work strong enough to raise heavy hammers; or a set of bells of different diameters, may be arranged concentrically within one another on one common axis, sufficiently small to be introduced into the frame of a clock, or even of a watch. The chime mechanism is sometimes so constructed, that it may be played like a piano, but with the hand instead of the fingers. This is covered with leather, that the blow on the key may be applied more forcibly. Difficult as the performance is, some players can execute compositions consisting of three parts, and even produce trills and *arpeggios*. Burney relates that the chime-player Scheppen, at Louvain, laid a wager with an able performer on the violin, that he would execute a difficult solo for the violin with the bells, and won his wager. Pottheff, organist and chime-player at Amsterdam, became blind in his 7th year, and received the above-named appointment in his 31st year; and although every key in his apparatus required a force equal to a two-pound weight, yet he played his bells with the facility of a performer on the piano-forte. Burney heard him perform some fugues in 1772.

CHIMNEY. How far the Greek and Roman architects were acquainted with the construction of chimneys, is a matter of dispute. No traces of such works have been discovered in the houses of Pompeii, and Vitruvius gives no rules for erecting them. The first certain notice of chimneys, as we now build them, is believed to be that contained in an inscription at Venice, over the principal gate of the *Scuola Grande di Sta. Maria della Carità*, which states that, in 1347, a great many chimneys were thrown down by an earthquake. Chimneys require much attention to make them secure and prevent their smoking, so great an annoyance to domestic comfort. It seems at present to be acknowledged, that it is much better to exclude the cold damp air from the flues, by narrowing the aperture at the top, than to give a larger vent to the smoke, at the risk of admitting a quantity of air to rush down the flue. For this reason, chimney-pots are of great use. In Prussia, where the architectural police (*Baupolizei*) is strict, great attention is paid to the erection of chimneys, and to the regular sweeping of them, the chimney-sweepers being bound to sweep the chimneys of a certain number of streets within a regular time; and, though the interference of a police in subjects of domestic economy is a delicate matter, the numerous fires which take place in other countries, from the careless construction of chimneys, seem to make some public supervision of their security desirable. The longer a chimney is, the more perfect is its draught, because the tendency of the smoke to draw upwards is in proportion to the different weight of the column of air included in a chimney and an equal column of external air. Short chimneys are liable to smoke, and fire-places in upper stories are, therefore, more apt to smoke than those in the lower ones. Two flues in the same chimney should not communicate with each other short of the top. Some chimneys, in large establishments in London, are very remarkable for their size.

The inconvenience which arises from the action of currents of air impeding the ascent of smoke, and as such diminishing the draught of the fire, has suggested the use of various contrivances to remedy this defect in chimneys. The one generally adopted is called a "revolving hood," which is defective on account of its weight. A lighter apparatus, similar in principle, but turning with less friction, has been the subject of a patent. It consists of a shield connected to a vane, which being turned round with the vane, protects the top of the chimney from any sudden gust of wind, and thereby enables the smoke to pass off without obstruction.

The accompanying figure shows the construction of the apparatus, the chimney-top being covered with an iron plate, having a circular opening in the middle for the passage of the smoke. There is a central shaft bearing on a cross bar at bottom, and carrying the vane at top. The upper plate is supported by pillars, upon which plate there are three anti-friction rollers touching the central shaft, and enabling it to turn in its bearing with very little friction. There are two arms extending from the central shaft to which the curved plate is affixed, constituting a shield.



The vane may be an arrow, or any other figure, which turning its point to the wind, carries round the guard into that situation which is exactly opposed to the wind, and thereby effectually prevents the wind blowing down the throat of the chimney; and of consequence enables the smoke to pass away freely into the atmosphere.

The form of the wind-guard may be varied; that shown in the figure is about one-third of a cylinder; it may, however, be straight, or at an obtuse angle bending inwards. It is farther proposed to place a bevel pinion on the central shaft which shall take into another pinion, on an horizontal shaft, and by that means cause two guards adapted to distinct chimneys to act simultaneously by the agency of one vane. The patentee proposes to form the plates and frame of the apparatus of cast iron, for the sake of cheapness and durability, and the shaft and guard of wrought iron or copper.

CHINA WARE. See PORCELAIN.

CHIRAGRA; that species of arthritis, or gout, which attacks the joints of the hand (the wrist and knuckles) and hinders their motions. It gradually deprives the hands of their flexibility, and bends the fingers, distorts them, and impedes their action, by the accumulation of a calcareous matter around the sinews, which finally benumbs and stiffens the joints.

CHIROLOGY; the language of the fingers, or the art of making one's self understood by means of the hands and fingers. It is an important means of communication for the deaf and dumb.

Chiromancy, or **Palmistry**; the pretended art of prognosticating by the lines of the hand. Its adherents maintain that human inclinations, faults, and virtues are designated in an infallible manner by the lines which divine Providence has originally drawn in the hands of all men. Traces of chiromancy are found in the writings of Aristotle, who asserts, for instance, that it is a sign of a long life if one or two lines run across the whole hand. The chiromancers quote some passages of the Bible to prove that their art is founded on the divine decrees, as the following:—"And it shall be for a sign unto thee upon thine hand, and for a memorial between thine eyes." (*Exodus* xiii. 9); and "He sealeth up the hand of every man, that all men may know his work." (*Job* xxxvii. 7.) In the middle ages chiromancy was cultivated; and, in the present age, the French chiromancer, Madame Lenormand, found, as she states, some eminent adepts in Paris, and in her travels to the different European congresses. The books in which chiromancy is explained and taught are numerous; and, in order to give dignity to the art, it has been connected with astrology. The gipsies are at present the principal professors of chiromancy, and people who have no faith in the art not unfrequently amuse themselves with their predictions.

Chlorine Acid. See Chlorine.

Chloride of Nitrogen. See Chlorine.

Chlorine. The discovery of this gas was made in 1770, by Scheele, and named by its discoverer, *dephlogisticated marine acid*. The term *dephlogisticated* had exactly the same import as that of *oxygenated*, soon afterwards introduced by Lavoisier. From its peculiar yellowish-green colour, the appellation of *chlorine* (from χλωρὸς, green) has been given to it. Chlorine gas is obtained by the action of muriatic acid on the peroxide of manganese. The most convenient method of preparing it is by mixing concentrated muriatic acid, contained in a glass flask, with half its weight of finely-powdered peroxide of manganese. On the application of a moderate heat, the gas is evolved, and should be collected in inverted glass bottles, filled with warm water. In order to comprehend the theory of this process, it must be premised that muriatic acid consists of chlorine and hydrogen. The peroxide of manganese is composed of manganese and oxygen. When these compounds react on one another, the peroxide of manganese gives up a portion of its oxygen to the hydrogen of the muriatic acid, in consequence of which water is generated, and chlorine (the other ingredient in muriatic acid) is liberated.

The method which is employed in the arts, and which is the most economical, is the following:—Three parts of common salt (muriate of soda) are intimately mingled with one of the peroxide of manganese, and to this mixture two parts of sulphuric acid, diluted with an equal weight of water, are then added. By the action of sulphuric acid on the muriate of soda, muriatic acid is disengaged, which reacts as before explained upon the peroxide of manganese; so that, instead of adding muriatic acid directly to the manganese, the materials for forming it are employed. Chlorine is gaseous under a common atmospheric pressure. It is twice and a half heavier than atmospheric air, or its specific gravity is 2.5. The gas has a yellowish-green colour. Of all the gases, it is the most insupportable in its action on the lungs.

When pure, it occasions immediate death if an animal is immersed in it; and even when largely diluted with common air, it cannot be respired with safety. It occasions a severe sense of stricture at the breast, which renders it impossible to make a full inspiration. This continues for a considerable time after it has been inspired, and has often produced a permanently injurious effect. When thoroughly dried, by exposure to fused chloride of calcium, it suffers no change, though cooled to 40°. When prepared over water, however, so as to contain a quantity of aqueous vapour, it condenses on the sides of the vessel even at a temperature of 40°; and if surrounded by snow or ice, it shoots into acicular crystals of a bright-yellow colour, and sometimes two inches in length, which remain attached to the sides of the vessel. This solid is a hydrate of chlorine, and, when heated to 50°, it melts into a yellowish oily fluid. Chlorine is absorbed by water, in a quantity which increases as the temperature diminishes. At 50°, the water takes up about twice its volume. The solution has a yellowish-green colour, and its odour is that of the gas itself. Its taste is rather styptic than sour, and the liquid, like the gas, has the property of destroying the vegetable colours. Hence it may be employed in bleaching. It is not changed by a boiling temperature. Solution of chlorine is decomposed, however, by exposure to the solar light; the chlorine attracts hydrogen from the water, forming muriatic acid, which remains dissolved, and pure oxygen is disengaged. Chlorine gas supports the combustion of a number of inflammable substances. A lighted taper burns in it, though feebly, with a red flame; phosphorus takes fire when immersed in it; and a number of the metals, as antimony, arsenic, copper, and others, if introduced into it in leaves or filing, burn spontaneously. Potassium and sodium burn vividly in it. In these cases, the inflammable or metallic substances are believed simply to unite with the chlorine.

Chlorine combines with many of these bases in more than one proportion. When in one proportion, the compound is called a *chloride;* when in two, a *bi-chloride*, or a *deuto-chloride*, &c. Whenever a metallic chloride, which is soluble in water, is thrown into that fluid, it is conceived to be instantly converted into a muriate; the water present is decomposed, its oxygen goes to the metallic base, and its hydrogen to the chlorine, and a muriate of an alkali, earth, or metallic oxide, is formed. Thus common salt when dry, is a chloride of sodium; it is no salt, containing neither acid nor alkali, but whenever it is dissolved in water, it is immediately transformed into a salt: the sodium attracts oxygen and becomes soda, and the chlorine takes hydrogen and becomes muriatic acid, and muriat of soda exists in the solution.

When any of the compounds of chlorine, with inflammable substances or metals, are subjected to the action of a galvanic apparatus sufficiently powerful to decompose them, the chlorine is always evolved at the positive pole of the battery, and the base at the negative pole. In this respect, and in its power of supporting combustion, chlorine is analogous to oxygen. One of the most important chemical properties of chlorine is displayed in its action on the vegetable colours. Many of them it entirely destroys; and even those which are the most deep and perma-

nent, such as the colour of indigo, it renders faint, and changes to a light yellow or brown. This agency is exerted by it, both in its gaseous and its liquid form. The presence of water is, however, necessary to this. Hence, when the gas destroys colour, it must, probably, be enabled so to do by the hygrometric water it contains. It is accordingly found, that when freed from this, it does not destroy the colour of dry litmus paper.

The destruction of colour appears to be owing to the communication of the oxygen of the water present to the colouring matter: the chlorine attracts the hydrogen of the water to form muriatic acid, and the evolved oxygen unites with the colouring matter, and by changing its constitution, alters its relation to light, so that the tint disappears. Berthollet applied this agency of chlorine to the process of bleaching, and with such success as to have entirely changed the manipulations of that art. The method of using it has been by Mr. Hall improved. It consisted at first, in subjecting the thread or cloth to the action of the gas itself; but the effect in this way was unequally produced, and the strength and texture were sometimes injured. It was then applied, condensed by water, and in a certain state of dilution. The thread or cloth was prepared as in the old method of bleaching, by boiling first in water, and then in alkaline lye; it was then immersed in the diluted chlorine; this alternate application of alkali and chlorine was continued until the colour was discharged. The offensive, suffocating odour of the gas rendered this mode of using it, however, scarcely practicable; the odour was found to be removed by condensing the chlorine by a weak solution of potash: lime, diffused in water, being more economical, was afterwards substituted. Under all these forms, the chlorine, by decomposing water, and causing oxygen to be imparted to the colouring matter, weakens or discharges the colour, and the colouring matter appears to be rendered more soluble in the alkaline solution, alternately applied, and of course more easily extracted by its action.

More lately, a compound of chlorine and lime has been employed, prepared by exposing slaked lime to chlorine gas: the gas is quickly absorbed, and the *chloride of lime*, as it is called, being dissolved in water, forms the bleaching liquor now commonly employed, and which possesses many advantages. In using it, the coloured cloth is first steeped in warm water to clean it, and is then repeatedly washed with a solution of caustic potash, so diluted that it cannot injure the texture of the cloth, and which is thrown upon it by a pump; the cloth is then washed and steeped in a very weak solution of chloride of lime, again washed, acted on by a boiling lye as before, and again steeped in this solution; and these operations are performed alternately several times. The cloth is lastly immersed in very dilute sulphuric acid, which gives it a pure white colour; after which it is washed and dried. Chloride of magnesia has been substituted with great advantage for that of lime, in whitening cloth for calico printing; the cloth when lime is used, retaining a little of it, which in the subsequent operation of clearing by immersion in weak sulphuric acid, forms sulphate of lime, which remains and affects the colours when it is dyed; while the sulphate of magnesia is so soluble, that it is entirely removed. Chloride of alumine has been employed to discharge the colour of the Turkey-red dye, which resists the action of other chlorides, and is only discharged by chlorine gas, by an operation very injurious to the workmen.

Another important application of chlorine gas is that of destroying or neutralizing contagion. Acid vapours, sulphurous acid in particular, under the form of the fumes of burning sulphur, had often been employed for that purpose; but chlorine, from the facility with which it decomposes the different compound gases that contain the elements of vegetable and animal matter, and which may be supposed to constitute noxious effluvia, is superior to any other agent, and is now universally employed for the purposes of fumigation. It is the only agent which can administer relief in cases of asphyxia from sulphurated hydrogen; and it has been found useful among such persons as are obliged to frequent places where contagious effluvia are constantly developed, to bathe the hands and arms with its solution. Chlorine, united with hydrogen, forms an important compound, called *muriatic*, or *hydrochloric acid gas*. With oxygen, it gives rise to four distinct compounds, which are remarkable for the feeble attraction of their constituent elements, notwithstanding the strong affinity of oxygen and chlorine for most elementary substances. These compounds are never met with in nature. Indeed, they cannot be formed by the direct combination of their constituents; and their decomposition is effected by the slightest causes. Notwithstanding this, their union is always regulated by the law of definite proportions, as appears from the following tabular view, illustrative of their composition.

	Chlorine.	Oxygen.
Protoxide of chlorine	36	8
Peroxide of chlorine	36	32
Chloric acid	36	40
Perchloric acid	36	56

Chlorine forms, along with nitrogen, one of the most explosive compounds yet known, and was the cause of serious accidents to M. Dulong, its discoverer, and afterwards to Sir H. Davy.

The *chloride of nitrogen* is formed from the action of chlorine on some salt of ammonia, chlorine and nitrogen being incapable of uniting, when presented to each other in their gaseous form. Its formation is owing to the decomposition of ammonia (a compound of hydrogen and nitrogen) by chlorine. The hydrogen of the ammonia unites with chlorine, and forms muriatic acid; while the nitrogen of the ammonia, being presented in its nascent state to chlorine, dissolved in the solution, enters into combination with it. The chloride of nitrogen has a specific gravity of 1.653; it does not congeal by the intense cold produced by a mixture of snow and salt. At a temperature between 200° and 212°, it explodes; and mere contact with most substances of a combustible nature causes detonation at common temperatures. The products of the explosion are chlorine and nitrogen.

Three distinct compounds of *chlorine* and *carbon* have of late been made known by Faraday; but for an account of these, as well as of the *chlorides of sulphur and of phosphorus*, and the *chloro-carbonic acid gas*, the reader is referred to the larger treatises on chemistry, it being incompatible with the plan of the present work to enter into those details which are not connected with the useful arts, or which are not absolutely necessary in order to afford a correct idea of

the mode of reasoning and general theory of the science.

Choc (from the French *choc*, the violent meeting of two bodies), in military language, signifies a violent attack. It is generally applied to a charge of cavalry. To give such an attack its full effect, it is necessary, 1. that the line be preserved unbroken, so that the attack shall take effect at all points at the same time; 2. that the horses be strong and heavy, that their momentum may be great; 3. that the charge be made as swiftly as possible, not merely for the sake of the physical effect, but also of the moral effect which it has on the enemy. This swiftness, however, must be attained gradually, increasing as the distance diminishes. The charge commences with a short trot; a long trot follows; at the distance of 150 paces, this is increased to a gallop; and 50 paces from the enemy, the horse must be put to his speed. A choc, whether successful or not, is of short duration.

Chocolate. See Cacao.

Choir; that part of the church where the choristers sing. In some old churches, the seats of the choristers, and others parts of the choir, are ornamented with admirable carved work.

Cholera; a genus of disease arranged by Cullen in the class *neuroses* and order *spasmi*. It is a purging and vomiting of bile, attended with anxiety, painful gripings, spasms of the abdominal muscles, and those of the calves of the legs. There are two species of this genus:—1. *Cholera spontanea*, which happens in peculiar seasons, without any manifest cause. 2. *Cholera accidentalis*, which occurs after the use of food that digests slowly and irritates. In warm climates it is met with at all seasons of the year, and its occurrence is very frequent. It usually comes on with soreness, pain, distension, and flatulency in the stomach and intestines, succeeded quickly by a severe and frequent vomiting, and purging of bilious matter, heat, thirst, a hurried respiration, and frequent but weak and fluttering pulse. When the disease is not violent, these symptoms after continuing for a day or two, cease gradually, leaving the patient in a debilitated and exhausted state; but where the disease proceeds with much violence, great depression of strength ensues, with cold clammy sweats, considerable anxiety, a hurried and short respiration, and hiccoughs, with a sinking, and irregularity of the pulse, which quickly terminate in death, an event that not unfrequently happens in the space of 24 hours. The appearances generally observed on dissection are, a quantity of bilious matter in the *primæ viæ*; the ducts of the liver relaxed and distended. Several of the viscera have been found in some cases displaced, probably by the violent vomiting.

In the above view of the disease we have treated it as the ordinary spasmodic cholera of this country, which has usually been more or less prevalent in the warmer seasons of the year; but, in the year 1831, Europe was visited by this disease, to an extent more fatal than had ever previously been felt in our climate. Whether or no the disease was contagious, appears still a matter of considerable doubt; but there certainly are many circumstances which would tend to a belief in that doctrine.

The disease was first felt to any extent in India, and the progress of its ravages, with the mode of treatment is well described by Mr. Skinner. He says, "Before we had reached Monghyr, where on the 20th of April we arrived, the cholera morbus broke out in our fleet, and reduced it terribly. Many of the Europeans died as well as the natives, and no evening passed without a funeral. The natives were either thrown overboard or deposited by the banks of the rivers to feed the vultures and the jackals; our own men were more decently buried in such graves as could quickly be scooped in the sand. Towards the end of April the disorder assumed a more alarming appearance, and every hour somebody was seized. Each officer was provided with a mixture, the principal ingredients of which were laudanum and brandy; and, in order that no time might be lost in making for the hospital boats, every vessel on board which a man might fall sick, was desired to bear down upon the nearest budgerow for assistance, when a wine-glass of the cholera mixture was administered. It was a melancholy sight to see five or six boats at a time draw out of the line and hasten towards the nearest officers in their rear. The moment the draught was received the disease in some measure seemed stayed, and the sick boat dropped quietly down to the hospital. It never was considered contagious, nor was any precaution used to separate the affected from the healthy; and we did not find that the remainder of the boat's crew was seized in consequence of any one of them having been attacked by it. It committed its ravages indiscriminately through the fleet. A native on board my budgerow died of the complaint in the course of a few hours; and although all the others were lying around him, it was not communicated to any of them. It has always seemed to me to be confined to particular spots: during the month of October, while we were in Fort William, the men who occupied one end of a lower room in the barracks were seized with it, while in every other part of the building they were perfectly healthy. This room had been undergoing repair, and was not properly flagged; the upper one of course was boarded: this circumstance proves it to have been entirely local; for there was a constant intercourse between all the parties, and it was not conveyed to the other quarters. It at length became general in the fort, which at that season of the year, the period of the breaking up of the rains, it usually does. A regiment of British soldiers on its march from Berhampore to Calcutta, halted one morning in the neighbourhood of a morass, and in a few hours afterwards several men were attacked with the cholera morbus, always the attendant evil of such a place: the commanding officer immediately struck the camp, and moved to about seven miles farther on; here the ground was drier and clearer; the sick men recovered, and there was no farther appearance of the disease. I am not very certain what the opinions of the faculty may be in the East, but as no precautions are taken against contagion, I conjecture they do not consider them necessary. I shall never forget the afternoon of our arrival at Patna: the cholera had been raging some time amongst the native population, and all the dead bodies seemed to have been placed on a clear spot without the city, and under the walls of some rich man's palace. The hot wind blew very violently, and we were long within sight of this place without being able to reach it; the water was very low, and several dead bodies that had been washed from the bank by the river, were stranded on the shallows in its centre. It was the 1st of May, and corruption was most rapid;

every breath of the sirocco blew poison; the scene was indescribable; bodies floated sometimes against our boats, for they were nearly all aground, and remained under the bows for an hour at a time, while others swam uninterruptedly down the stream with flocks of birds upon them; little could be heard but the noise of the vultures tearing off the flesh with their beaks, while the crows jangled in their quarrels for the morsels that fell from them. About sun-set we reached the shore; but, alas! could get no farther than the burial-ground, along the edge of which we were obliged to moor. It was strewed with skulls and "dead men's bones," and the air was pestilence itself. The jackals and the wild dogs skulked away from the mangled limbs as we approached, while the vultures, the very sight of which speaks of the charnel-house, rose from the half-eaten body, and, hovering for a moment above it like evil spirits, descended to the completion of their horrible repast. There were a great number of the Hargila large storks, known by the name of adjutants in India, from their measured step, stalking over the ground; they are always close attendants upon Europeans, and had come from the station of Dinapore to share in the feast that cholera had prepared for them."

On the 26th of June, 1831, 580 persons were attacked in St. Petersburg alone, and out of that number 280 died. The disease continued its ravages, and gradually spread over the whole of Europe. From our own country it passed to America, and though its destructive progress has not been on so extended a base as in Europe, yet the mortality in several of the states of the Union has been of a most fearful character.

We may now give the mode of treatment pursued by one of the most intelligent practitioners who has yet written on the subject of cholera,—we mean Mr. Le Fevre. He says, "the following is the practice I have almost universally adopted in cases of cholera where I have been called in at the commencement. If the patient is robust, the pulse still perceptible, and the system not much reduced by evacuations, I order from six to eight ounces of blood to be drawn from the arm, the patient being first put to bed, in the recumbent posture.

"The following draught is then given: Laudanum and æther, of each twenty-five drops, strong peppermint water, an ounce and half.

"If this be rejected, it should be repeated immediately; if the second be likewise not retained, then a clyster of linseed tea with fifty drops of laudanum should be administered.

"It often happens that the patient after taking the first dose falls asleep, and awakes in perfect health.

"A large sinapism to the abdomen, and bottles of hot water to the feet, should not be omitted; if these means produce speedy relief, an ounce of castor oil should be prescribed as soon as the stomach and bowels are quiet.

"Such is the most successful practice in slight cases, and I believe many a severer attack has been prevented by this method of proceeding; for I had given full directions to many of my patients how to act in case of not immediately finding medical aid, and all the houses I attended were prepared with these draughts.

"It may have happened that some have been taken unnecessarily; but I am convinced that many a case has been cut short by immediately applying to this remedy.

"It would be well if this always succeeded; but often after a short respite the symptoms return, the vomiting continues, accompanied with spasms of the abdominal muscles and calves of the legs.

"In such cases, three grains of bismuth should be given every two hours, and continued till the vomiting has ceased, and the spasmodic action greatly or wholly subsided. The bismuth should then be discontinued, for the symptoms which seemed to demand it have subsided; and in this sense only I considered it useful, and by no means a specific for the disease. If it be continued for any length of time, it is in many cases followed by congestion of the brain.

"If this mode of employing succeeds, as soon as the necessity for continuing it ceases, then the castor oil should be resorted to as in the first-mentioned instance, for this is a *sine qua non*. When the shock is thus broken and the patient begins to recover, nothing farther need be done than to keep the bowels open and return to food gradually, beginning by mucilaginous diet, aud by degrees adding veal and chicken broth to the meal.

"If slight delirium should occur, a few leaches to the temples, and a blister to the back of the neck, will generally relieve it.

"If the means above detailed did not succeed, I have not myself been able to succeed by any other. I do not mean to assert that these are the only means I have employed, nor that nothing more is necessary; but they are those upon which I rely the most, and if employed early in the attack, will often be attended with success.

"Many other symptoms require attention even under this plan of proceeding.

"The cramps may often be relieved by friction with the hands, or with some narcotic and stimulating embrocations.

"The colicky pains which remain afterwards, and are renewed by every attempt to go to stool, are best relieved by clysters of starch and opium.

"Cataplasms of hemlock or henbane applied over the whole surface of the abdomen, and renewed every four hours, are of much service in relieving these after-pains.

"The nausea and vomiting are more relieved by the saline effervescing draught than any other remedy. Cold drinks do not seem to be more prejudicial than warm, and when much desired by the patient, should be given freely. Lemonade iced has often been taken with advantage, and even the lower orders have drank their quaffs as usual, and with seeming benefit.

"The nitric acid may be given here also with great benefit as a common drink. Fifty drops of the diluted acid added to a pint of water, sweetened to the taste, is a grateful beverage.

Choral (derived from *chorus*); a term applied to vocal music, consisting of a combination of different melodies, and intended to be performed by a plurality of singers to each part; as *choral anthem, choral service*. In Germany, this term is applied to the music of hymns, in the composition of which the Germans are so much distinguished.

Chord, in *Music*; a combination of two or more sounds according to the laws of harmony. The word

chord is often used in counterpoint; as *fundamental chord, accidental, anomalous,* or *equi vocal, transient chord.*

CHOREGRAPHY; an invention of modern times; the art of representing dancing by signs, as singing is representing by notes. It points out the part to be performed by every dancer—the various motions which belong to the various parts of the music, the position of the feet, the arms, and the body, &c. The degree of swiftness with which every motion is to be performed may be thus indicated, by which all becomes as intelligible to the dancer as a piece of music to the musician. Drawings to assist the tactician, by designating the position, motion, and evolutions of troops, have also been called *choregraphical drawings.*

CHOROGRAPHY; the description of a single district, in contradistinction to *geography* (the description of the earth). The art of drawing maps of particular districts is also called *chorography.*

CHORUS, in the drama. This was, originally, a troop of singers and dancers, intended to heighten the pomp and solemnity of festivals. This, without doubt, was at first the purpose of tragedy and comedy, of which the chorus was originally the chief part, in fact, the basis. In the sequel, it is true, the chorus became only an accessory part. During the most flourishing period of Attic tragedy, the chorus was a troop of male and female personages, who, during the whole representation, were bystanders or spectators of the action, never quitting the stage. In the intervals of the action, the chorus chanted songs, which related to the subject of the performance, and were intended either to augment the impression, or to express the feeling of the audience on the course of the action. Sometimes it even took part in the performance, by observations on the conduct of the personages, by advice, consolation, exhortation, or dissuasion. It usually represented a part, generally the oldest portion of the people, where the action happened, sometimes the counsellors of the king, &c. The chorus was an indispensable part of the representation. In the beginning, it consisted of a great number of persons, sometimes as many as fifty; but the number was afterwards limited to fifteen. The exhibition of a chorus was in Athens an honourable civil charge, and was called *choragy.* The leader or chief of a chorus was called *coryphæus,* who spoke in the name of the rest, when the chorus participated in the action. Sometimes the chorus was divided into two parts, who sung alternately. The divisions of the chorus were not stationary, but moved from one side of the stage to the other; from which circumstance the names of the portions of verse which they recited, *strophe, antistrophe,* and *epode,* are derived. But it cannot be determined in what manner the chorus sung. It is probable that it was in a sort of solemn recitative, and that their melodies, if we may call them so, consisted in unisons and octaves, and were very simple. They were also accompanied by instruments, perhaps flutes. With the decline of ancient tragedy, the chorus was omitted. Some tragedians of the present age, of whom Schiller was the first (see his prologue to the *Bride of Messina*), have attempted to revive the ancient chorus.

Chorus, in music, in its general sense, denotes a composition of two, three, four, or more parts, each of which is intended to be sung by a plurality of voices. It is applied also to the performers who sing those parts. These choruses are adapted to express the joy, admiration, grief, adoration, &c., of a multitude, and sometimes produce much effect, but are very difficult for the composer.

CHROMATE OF IRON, or CHROMEISENSTEIN, is a mineral substance of very considerable interest, as affording one of the most beautiful and durable pigments in the arts. It is found disseminated in grains and imperfectly crystallized masses—occasionally in regular octoedral crystals, its primary form—of a black colour, and shining and somewhat metallic lustre. It scratches glass, is opaque, and has a specific gravity of 4.03. According to Vauquelin, that of France consists of 43 chromic acid, 34.7 oxide of iron, 20.3 alumine, silex 2. But chemists, at the present day, consider the chrome in this mineral in the state of an oxide, and not of an acid; accordingly the mineral is now more correctly denominated the *ferruginous oxide of chrome.* It is found in great abundance in Maryland, at the Bare Hills, near Baltimore, and is contained in a steatitic or serpentine rock.

CHROMATIC, in *Music;* one of the three ancient genera—diatonic, chromatic, and enharmonic. The word *chromatic* has been adopted, as it is believed, because the Greeks were in the habit of designating this genus by characters of various colours, or, as some say, because the chromatic genus is a mean between the other two, as colour is a mean between white and black (this seems to be a very poor explanation); or, lastly, because the chromatic genus, by its semitones, varies and embellishes the diatonic, thus producing an effect similar to that of colouring. In modern music, the word *chromatic* simply means a succession of semitones, ascending or descending. Thus the expressions *chromatic semitone* (the interval which is found between any given note and that same note raised by a sharp or lowered by a flat), *chromatic scale, chromatic modulation,* are terms in use.

CHROME; the name of a metal, which, combined with oxygen so as to be in the state of an acid, was discovered by Vauquelin, in an ore of lead from Siberia. This metal has since been found combined with iron in the United States, and at Unst, one of the Shetland isles. It appears also to be the colouring principle of the emerald and the ruby, and has received its name from its property of assuming brilliant colours in the combinations into which it enters. Chrome, which has hitherto been procured in very small quantities, owing to its powerful attraction for oxygen, may be obtained by mixing the oxide of chrome with charcoal, and exposing the mixture to the most intense heat of a smith's forge. It is brittle, of a grayish-white colour, and very infusible. Its specific gravity is 5.9. Chrome unites with oxygen in three proportions, forming two oxides and one acid. The protoxide is of a green colour, exceedingly infusible by itself, but with borax, or vitreous substances, it melts, and communicates to them a beautiful emerald-green colour. Indeed, the emerald owes its colour to this oxide. The protoxide is employed at the manufactory of Sevres, in France, to give a fine deep green to the enamel of porcelain. It is applied without a flux, and melted with the enamel. Chromic acid, however, is the most important of the compounds formed by this metal along with oxygen. It is usually prepared for chemical purposes by mixing solutions of nitrate of barytes and chromate of

potash, and digesting the chromate of baryt... is formed in dilute sulphuric acid. This ...s the barytes, and the chromic acid is procu...y evaporation, in crystals of a fine ruby-r...our. It is very soluble in water, has a sour m...ic taste, and all the characters of a strong acid. ...ombines with the alkalies, earths, and meta...oxides, forming salts, many of which have very... colours.

The alkaline chromates ar...uble and crystallizable. They are of a yello... red colour, the neutral chromates being co...nly yellow, and the bi-chromates red or dee...nge. The best known of these is the bi-chro... of potash, which is one of the most splendid... at the same time one of the most useful sa... The manner in which it is formed is as follows. Chromate of iron, or rather ferruginous oxide ... chrome, reduced to fine powder, is mixed w... half its weight of nitrate of potash, and heated ...ongly for an hour or two in crucibles. The result... masses are then repeatedly digested with wate... nd the coloured liquids, which are slightly alk..., saturated with nitic acid, and concentrated by ...poration till no more crystals of nitre can be o...ned from them. The yellow liquid being now ...side for a week or two, deposits a copious crop ...ystals, whose form is that of a four-sided prism, ...inated by octihedral summits. Their colour is an ...nse lemon-yellow, with a slight shade of orange. ... parts of water at 60° dissolves about 48 parts; ...t boiling water dissolves almost any quantity. Its ...lution in water decomposes most of the metallic ...lts; those of mercury of a fine red; copper and ...on of a reddish brown; silver, dark-red, and lead, ... a beautiful yellow colour, now much used as a ...gment under the name of *chrome yellow*. Chrome ...ellow is largely manufactured in the United States, ...t Baltimore, near which place is found one of the most remarkable deposits of ferruginous oxide of chrome in the world. The process consists in adding a solution of acetate of lead (or sugar of lead) to the rough solution of chromate of potash, from which the nitrate of potash has been just separated by crystallization. The acetate of lead is added as long as any sediment falls. The liquid is then filtered, and the yellow precipitate left on the filters dried for sale.

Chromic Acid. See Chrome.

Chronic; a term applied to diseases which are of long duration, and mostly without fever. It is used in opposition to the term *acute*, which is applied both to a pungent pain and to a disease which is attended with violent symptoms, terminates in a few days, and is attended with danger. On the other hand a *chronic* disease is slow in its progress and not so generally dangerous.

Chronometer; a time-piece of a peculiar construction, at present much employed by navigators in determining the longitude at sea. In general chronometers are much larger than common watches, and are hung in gimbals, in boxes six or eight inches square; but there are also many pocket chronometers which, externally, have all the appearance of the better sort of pocket watches, and internally differ from these only in the construction of the balance. The balance and hair-spring are the principal agents in regulating the rate of going in a common watch, being to this what the pendulum is to a common clock; and this spring in the former, like the pendulum in the latter, is subject to expansions and contractions under different degrees of heat and cold, which of course affect the speed or rate of the machine; and the methods of correcting this inaccuracy mark the difference between the watch and chronometer. These are very numerous. With British and American navigators chronometers are more common than with those of any other nation. An instrument under the name of *chronometer* is also used by musicians for the accurate measurement of time.

Chyle, or Chyme, in animal economy. In the process of digestion the food is subjected to a temperature usually above 90° of Fahrenheit. It is mixed with the gastric juice, a liquor secreted by the glands of the stomach, and is made to undergo a moderate and alternate pressure by the contraction of the stomach itself. It is thus converted into a soft, uniform mass, of a grayish colour, in which the previous texture or nature of the aliment can be no longer distinguished. The *chyme*, as this pulpy mass into which the food in the stomach is resolved is termed, passes by the pylorus into the intestinal canal, where it is mixed with the pancreatic juice and the bile, and is still exposed to the same temperature and alternating pressure. The thinner parts of it are absorbed by the slender tubes termed the *lacteals*. The liquor thus absorbed is of a white colour; it passes through the glands of the mesentery, and is at length conveyed by the thoracic duct into the blood. This part of the process is termed *chylification*, and the white liquor thus formed *chyle*. It is an opaque, milky fluid, mild to the taste. By standing for some time, one part of it coagulates; another portion is coagulated by heat.

The chyle, after mixing with the lymph conveyed by the absorbent vessels, is received into the blood, which has returned from the extreme vessels before this passes to the heart. All traces of it are very soon lost in the blood, as it mixes perfectly with that fluid. It is probable however that its nature is not immediately completely altered. The blood passing from the heart is conveyed to the lungs, where it circulates over a very extensive surface presented to the atmospheric air, with the intervention of a very thin membrane which does not prevent their mutual action.—During this circulation the blood loses a considerable quantity of carbon, part of which it is probable is derived from the imperfectly assimilated chyle, as this originating in part from vegetable matter, must contain carbon in larger proportion than even the blood itself.

Cicuta. The cicuta, or common American hemlock, is one of the most valuable and important of medicinal vegetables. It is a plant indigenous in most temperate climates, and is found commonly along walls and fences, and about old ruins and buildings. The most common form in which it is administered is the extract, which is given in pills. Of this, from 12 to 60 grains per day may be taken for a long time. It is invaluable in all chronic inflammations, and enlargements of glandular parts, as the liver, the womb, &c., tumours of which it will sometimes remove in a space of time surprisingly short. Its use may be continued, if necessary, for a long time, and it is not found to debilitate or injure the system in the manner that mercury always does when long used. Its green leaves, stirred into a soft poultice, form an excellent application for painful sores and ulcers; and the same leaves, dried and rubbed fine, make, when mixed with cerate or lard, a capital

ointment for irritable sores, with which a poultice does not agree.

Cider; a liquor made from the juice of apples. The quality of this popular beverage depends principally on the following particulars, viz.:—1. kind of fruit; 2. condition of the fruit when ground; 3. manner of grinding and pressing; 4. method of conducting the requisite fermentation, and precautions to be taken against its excess.

1. The characteristics of a good cider-apple, are, a red skin, yellow and often tough and fibrous pulp, astringency, dryness, and ripeness at the cider-making season. Mr. Knight, asserts, that, "when the rind and pulp are green, the cider will always be thin, weak, and colourless; and when these are deeply tinged with yellow, it will, however manufactured, or in whatever soil the fruit may have grown, almost always possess colour and either strength or richness." It is observed by Crocker, in his tract on *The Art of making and managing Cider*, that the most certain indications of the ripeness of apples are the fragrance of their smell, and their spontaneously dropping from the trees. When they are in this state of maturity, in a dry day, the limbs may, he says, be slightly shaked, and partly disburthened of their golden store; thus taking such apples only as are ripe, and leaving the unripe longer on the trees, that they may also acquire a due degree of maturity. Mr. Buel observes, that "the only artificial criterion employed to ascertain the quality of an apple for cider, is the specific gravity of its *must*, or unfermented juice; or the weight compared with that of water. This, says Knight, indicates, with very considerable accuracy, the strength of the future cider. Its weight and consequent value are supposed to be increased in the ratio of the increase of saccharine matter." Mr. Knight says that the strongest and most highly-flavoured cider which has been obtained from the apple, was produced from fruit growing on a shallow loam, on a limestone basis. All the writers on the subjest seem to agree that calcareous earth should form a component part of the soil of a cider orchard. Coxe says the soil which yields good wheat and clover is best for a cider orchard. Mr. Buel states, "My own observation would induce me also to prefer a dry and somewhat loose soil, in which the roots destined to furnish food for the tree and fruit may penetrate freely, and range extensively in search of nutriment."

2. *Condition of the fruit.* Fruit should be used when it has attained full maturity, and before it begins to decay. The indications of ripeness we have above stated. Each kind of apple should be manufactured separately, or, at least, those kinds only should be mixed which ripen about the same time. Mr. Buel says, "The apples should ripen on the tree, be gathered when dry, in a cleanly manner. spread in an airy, covered situation, if practicable, for a time, to induce an evaporation of aqueous matter, which will increase the strength and flavour of the liquor, and be separated from rotten fruit, and every kind of filth, before they are ground."

3. *Grinding*, &c. The apples should be reduced, by the mill, as nearly as possible to an uniform mass, in which the rind and seeds are scarcely discoverable, and the pomace should be exposed to the air. Knight ascertained by experiments, that, by exposing the reduced pulp to the operation of the atmosphere for a few hours, the specific gravity of the juice increased from 1.364 to 1.678; and, from the experiment being repeated in a closed vessel with atmospheric air, he ascertained the accession to be oxygen, which according to Lavoisier, constitutes 64 per cent. of sugar. For fine cider, he recommends that the fruit be ground and pressed imperfectly, and that the pulp be then exposed 24 hours to the air, being spread and once or twice turned, to facilitate the absorbtion of oxygen; that it be then ground again, and the expressed juice be added to it before it is again pressed.

4. *Fermentation.* The vinous fermentation commences and terminates at different periods, according to the condition and quality of the fruit, and the state of the weather. According to Knight, the best criterion to judge of the proper moment to rack off (or draw the liquor from the scum and sediment), will be the brightness of the liquor which takes place after the discharge of fixed air has ceased, and a thick crust is collected on the surface. The clear liquor should then be drawn off into another cask. If it remains bright and quiet, nothing more need be done to it till the succeeding spring; but if scum collects on the surface, it must immediately be racked off again, as this would produce bad effects if suffered to sink.

Among the precautions used to prevent excessive fermentation is *stumming*, which is fuming the cask with burning sulphur. This is done by burning a rag impregnated with sulphur in the cask in which the liquor is to be decanted, after it has been partly filled, and rolling it, so as to incorporate the liquor with the gas. A bottle of French brandy, or half a gallon of cider-brandy, added to a barrel, is likewise recommended to be added as soon as the vinous fermentation is completed.

Cinchona. See Bark.

Cinnabar; a preparation of mercury, which see.

Cipher. See Arithmetic and Numerals.

Circle; a plane figure comprehended under a single line which returns into itself, having a point in the middle, from which all the lines drawn to its circumference are equal. This point is called the *centre*, and these lines the *radii*. Although, properly speaking, it is the space included within the periphery or circumference, yet, in the popular use of the word, *circle* is frequently used for the periphery alone. From the geometrical definition of the circle, it appears that its magnitude is dependent upon the magnitude of its radius or its diameter; that is, a line which touches two points of the circumference, and passes at the same time through the centre, or, which is the same thing, a line equal to twice the length of the radius. The surface of the circle is equal to the product of the circumference and half the radius. If there existed a rational proportion, that is, a proportion to be expressed in whole numbers, of the surface of the circle to a square surface, there would be at the same time a rational proportion between the diameter and the circumference. But, from geometrical reasons, no rational proportion of the diameter to the circumference is possible; it can be expressed only by approximation. However, the proportion thus obtained is quite as accurate as is necessary for any purpose in the applied mathematics. Yet there have always been instances, and some of a very late date, of men labouring long and intensely in searching for the square equal to the surface of the circle, and who often believed that they had actually solved the problem. In the approximate proportion, if the diameter is called 1, the

circumference will be equal to 3.1415926535.... Francis Vieta obtained the proportion to this number of figures. Afterwards it was farther determined by Adrianus Romanus to 15, by Ludolphus of Cologne (often improperly called *von Keulen*) to 35 (from him it is often called the *Ludolphic number*), by Sharp to 72, by Machin to 100, by Lagny to 126, and lastly, in an Oxford manuscript it was obtained up to 156 decimals. Archimides first estimated the proportion of the diameter to the circumference to be as 7 to 22, or as 1 to 3.142.....; after him, Metius, as 113 to 355, or as 1 to 3.1415929, which is correct to 6 decimals, and sufficiently accurate for most purposes. Every circle is divided into 360 degrees, and by its arcs all angles are measured. The circle therefore is one of the most important geometrical figures, and an accurate division of it is requisite for measuring the angles under which distant objects appear (upon which surveying, astronomical observations, &c. rest) —a very desirable object, for which many prizes have been offered by learned societies.

Circular Motion. A body in motion, which is continually impelled by some power towards a fixed point out of its original direction, is obliged to describe a curvilinear path round this point. A stone, slung round by a string, moves in a circle, because it is drawn toward the hand in every point of its path. The moon moves in a circle round the earth, because it gravitates towards the earth, and is thus drawn from the rectilinear direction, which it would otherwise pursue. In such cases, the point to which the body constantly tends is called the *centre of the forces*; the force itself by which it is impelled is called the *centripetal force*; that by which it strives to fly from the centre is called the *centrifugal force*; and the motion which is produced by these two forces, the *circular motion*. All the planets in the solar system are carried round the sun, and the satellites round their planets, by these forces. (See Central Forces.) The theory of circular motion is a subject of celestial mechanics, on which Newton composed his *Principia Mathematica Philosoph. Natural.* and Laplace his *Mécanique Céleste*, &c. As the model of a concise and beautiful exposition, we recommend the article under this head in Gehler's *Dictionary of Natural Philosopby*, and the introduction to *Ferguson's Lectures*.

Circular Saws, which revolve upon an axis, are preferable to straight saws, because they act continually in the same direction, and no force is lost by a backward stroke. At the same time, they can work with greater velocity, and therefore, cut more smoothly. Their size, however, is limited, because they waver and bend out of the proper plane if made too large, and if they were made so as not to waver, they would be too thick. Slitting of timber, therefore, is not often performed with them, but they are much used for cutting thin layers of mahogany for veneering, for in this case, the saw can be sufficiently strengthened towards the centre. Great velocity increases much the steadiness of a circular saw.

Circulating Medium. The expression *circulating medium* is now much more frequently used than formerly. It means the medium of exchanges, or purchases and sales, whether this medium be gold or silver coin, paper, or any other article, as oxen, tobacco, iron, slaves, usually employed in any place as the measure of the values of other articles, and is thus of a more comprehensive signification than the term *money*, which, though it applies to gold and silver coin, paper currency, and some other of the various articles used for the above purpose, does not comprehend them all, since oxen, which have by some nations, at some periods, been adopted as the measure of the comparative values of articles of commerce, would hardly be considered as coming under the denomination of *money*. It is hardly possible to imagine a people to be without a circulating medium of some description; and accordingly, we find all the tribes of savages hitherto discovered referring to some article in estimating the value of the various commodities which compose their capital. Captain Franklin says, the Krees Indians use beaver skins as their medium, and estimate the value of things by a certain number of their skins. The people of Virginia in the earlier periods of their colonial history estimated value by pounds of tobacco. In some parts of Africa, a species of small shells, cowries, are the medium of exchanges. But from the earliest times, the precious metals, where they could be had, have been preferred for this purpose, because their weight, fineness, and consequent value, could be more accurately ascertained than those of any other article, and thus comprise a sufficient value in a small compass and weight to be a convenient medium.

Many species of precious stones comprise a greater value in the same bulk and weight than either gold or silver, but their value cannot be so precisely estimated, nor are they found in sufficient quantities. Platina would be as convenient a medium as either gold or silver, provided it should continue to retain its present value; but it has not as yet been produced in sufficient abundance. It is one essential quality of a circulating medium, that it should have an intrinsic marketable value. Gold and silver for instance, besides answering as a medium, have as positive a market value as iron, tin, leather, or corn. This value is derived from their utility in the useful and ornamental arts; and it may be more precisely ascertained than the value of most other articles, since an agreement for a certain number of beaver skins, a certain quantity of tobacco, and still more for a certain number of cattle, admits of some doubt and dispute as to the quality; but an agreement for a certain weight of gold, of given fineness, admits of no dispute; it can be reduced to the utmost certainty. But we see other kinds of currency, which apparently answer the purpose of a circulating medium, and which have very little value. A small piece of paper, not worth intrinsically one penny, passes for many thousand pounds; and this sometimes leads people into the mistaken notion that intrinsic value is not an essential quality in the public currency. But we must look at what is printed or written on this paper, to learn why it passes for currency. It bears a promise that the holder shall be entitled to a certain number of pounds; of course, a certain quantity of gold and silver of a certain fineness. If this promise is valid, and will be kept, then the real medium is gold and silver, though this gold and silver may be locked up in a bank. But it may be said, that there is not, in the banks, where bank paper circulates, and perhaps not in the community, more than one pound in silver or gold for four pounds promised in the paper in circulation. How then can four pounds of paper be redeemed by one of silver? This is very easy. One holder of a

paper pound demands the silver at the bank, and passes it off, or keeps it in his purse. Now if the bank can induce this person, or the one to whom he passes the pound, to let them have it again, that is, to loan it to them, or to take something in exchange for it, they can then, with the same silver pound, redeem the second paper one, and so on. Thus a bank that has capital and a good credit, will be always able to reclaim and use the same specie successively to redeem its paper, and if it be skilfully conducted, it will always be able to command it as fast as its bills can be collected and presented for payment. A community, therefore, which only uses specie and redeemable paper as currency, has, to all practical purposes, a specie medium. The paper is, in short, so much specie for all practical purposes, for it will command gold and silver. Here then is evidently an advantage gained; for if a bank, by putting one pound in its vaults, can loan out four pounds on interest, it makes a great income on its capital, while the community loses nothing, but gains rather; for this paper is much more convenient for transportation, and equally convenient in all other respects.

It is a great object in every community to gain this advantage, arising from multiplication of money. Individuals, if not prohibited by the laws, will soon issue their paper money, and many of them make promises of paying pounds which they cannot fulfil, and thus the public be defrauded. On the other hand, the government often makes the bubble by the issue of paper money, or promises of payment never to be fulfilled.

There has rarely, if ever, been an instance of a government issuing paper money, and redeeming it punctually, and to its full nominal amount. Innumerable issues of this sort of circulating medium were made by the American colonies before the establishment of the independence of the United States; and during the war of independence, the country was inundated with what was called *continental money*, which was never redeemed.

Russia and Austria have this species of currency in circulation, always depreciated, as is usual with such money. Formerly, the sovereigns of Europe had a practice of debasing the current coin, when they wished to levy a tax in disguise, so as to make the copper with which they alloyed the silver, pass as of the value of silver. But in modern times, instead of debasing the coin, the usual resort is to a government bank or to government paper.

Government paper, issued as the ordinary currency, usually proves to be a bubble. And it may be taken for a general rule, that no currency is safe which is not of an intrinsic value, or is not based upon capital sacredly pledged to its redemption. The question then recurs, why the government may not pledge a certain amount of capital for the redemption of its paper. The reason is, that this capital must be managed, and a vast deal of skill and economy is requisite in managing a redeemable paper currency; and of all managers, the agents of a government are the least thrifty and economical. Besides, the government will ruin the credit of its own paper by excessive issues in its exigencies in times of war, when the effects of a destruction of its credit are the most disastrous. The government, therefore, ought never to trust itself to be a banker, or to issue paper money, except in desperate circumstances or pressing exigences, when no other measure can be resorted to, and when what would otherwise be wrong and dishonest, is excused for the sake of preventing the greatest national calamities. If, then, neither the government nor individuals can safely supply a circulating medium of promises, what system can be safely adopted, which shall afford all the advantages of a multiplication, in effect, of the medium of intrinsic value, namely, the gold and silver? ' Undoubtedly the system of bank circulation, whereby a certain capital is sacredly pledged to the redemption of the promises of payment of money made in the circulating bills. A well contrived, skilfully conducted system of banking, connected with one of circulation, is one of the greatest triumphs of national economy. The interest, as well as the reputation of individuals, is thus pledged in support of the system, and in furtherance of the general industry and prosperity. But shall individuals reap all the advantages of the practical multiplication of capital in consequence of supplying a currency based upon, but not consisting exclusively of specie? By no means. The government may indirectly reap greater advantages from this system than they possibly can from an attempt at becoming themselves bankers for the community, by sharing the profits with those who actually conduct the business. It is one of the proper and most important functions of the government to regulate the currency. It is bound to interfere, with proper restrictions, for preventing the frauds and bubbles to which individual enterprise and speculation inevitably lead if let loose in the career of credit; and it has a profit in so doing, by reaping some of the advantages of a bank circulation, and thus gaining an income without in fact levying a tax. As long as the government does not bear oppressively upon this species of monopoly, by attempting to levy an excessive tax for the privilege, and thus discouraging it, a liberal income may be derived from the substitution of promises on paper, for the ordinary purposes of circulation and exchange, and at the same time, such guarantees may be provided as to prevent abuse and fraud, and render this currency as safe as that of specie. We have hitherto spoken of the subject generally under MONEY; we purpose especially examining our own medium of circulation.

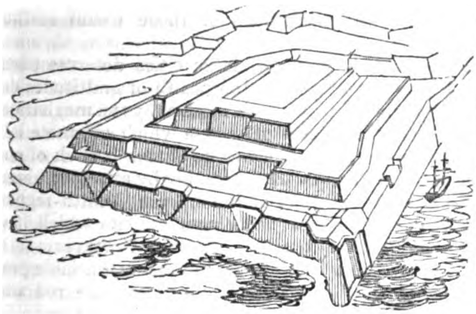
CIRCULATION OF THE BLOOD. See ANATOMY and HEART.

CIRCUMVALLATON, or LINE OF CIRCUMVALLATION, in military affairs, implies a fortification of earth, consisting of a parapet and trench, made round the town intended to be besieged, when any molestation is apprehended from parties of the enemy which may march to relieve the place.

CITADEL, or CITTADEL (a diminutive of the Italian *città*, city; signifying *little city*), in fortification; a kind of fort, consisting of four, five, or six sides, with bastions, commonly joined to towns, and sometimes erected on commanding eminences within them. It is distinguished from a castle by having bastions.

An example of the military importance of a scientifically erected citadel has lately been adduced in the protracted resistance made by General Chassé in the works of Antwerp; an account of which will be found in the SECOND DIVISION of our work, under that article. We now give an example of one of the strongest citadels in the world—we mean that which

protects the harbour and city of La Valette, in Malta. It was planned by the knights, during their powerful military sway in that island; and, if properly defended, may be said to bid defiance to any attacking force.



Cities, *Medical Statistics of*. It is well known that, in any given country, the deaths in a city are more numerous than those in the rural districts. This difference is principally felt in the first five years of life, when many more die in London than in the country. From 5 years of age to 20, the deaths in London are fewer. Between 20 and 50, many more die in London, on account of the large annual influx from the country. In all cities, a large portion of disease and death is to be assigned to the constant importation from the country of individuals who have attained to maturity, but having been previously habituated to frequent exercise in a free atmosphere and to a simple, regular diet, are gradually sacrificed to confined air, sedentary habits, or a capricious and over-stimulating diet. These causes are not equally fatal to those who have passed their early years within the walls of a city; and after the age of 50 the proportion of deaths in London is smaller than in the country. Jenner and Dr. Baron have made some curious experiments on animals, which indicate that a loss of their open range and natural nourishment has with them also a tendency to disorganize and to destroy.

Dr. Baron placed a family of young rabbits in a confined situation, and fed them with coarse green food, such as cabbage and grass. They were perfectly healthy when put up. In about a month one of them died. The primary step of disorganization was evinced in a number of transparent vesicles studded over the external surface of its liver. In another, which died nine days after, the disease had advanced to the formation of tubercles on the liver. The liver of a third, which died four days later still, had nearly lost its true structure, so universally was it pervaded with tubercles. Two days subsequently a fourth died. A considerable number of hydatids were attached to the lower surface of the liver. At this time Dr. Baron removed three young rabbits from the place where their companions had died to another situation, dry and clean, and to their proper and accustomed food. The lives of these remaining three were obviously saved by this change. He obtained similar results from experiments of the same nature performed on other animals.

In *Glasgow* the average annual mortality is about 1 in 44 persons.

In *Paris* the poor and the rich occupy the two extremities of the scale. The mortality in the one is nearly double that in the other. The average is 1 in 32. The number of violent deaths in 1823 was 690, of which 390 were cases of suicide. Reviewing, on one side, the great political, moral, and physical events which have occurred at Paris during a succession of years, and, on the other, the progress of its population, Villerme has ascertained, that whenever the people have suffered from any cause, the deaths have correspondingly increased, the births have decreased, and the mean duration of life has been shortened. In periods of prosperity, he has found results directly opposite to these. The mean duration of life in Paris is 32 years and some months It was formerly estimated that one-third of the inhabitants of Paris died in the hospitals; but Dupin has lately calculated that half the deaths in Paris take place in the hospitals and other asylums of charity. Not a fourth part of the inhabitants are buried at private cost.

In *Geneva*, the average mortality for the four years ending in 1823, was 1 in 43, which is a greater mortality than in some of the largest manufacturing towns, as Manchester and Birmingham.

It is curious that the burials exceed the births in the Russian capital, by 134 to 100. The Russians attempt to explain this by the annual influx of persons from the provinces. But this influx is not peculiar to St. Petersburg. The last-mentioned city and Stockholm are the only known metropolitan cities which present the preponderance of death over production. The annual mortality of the Russian capital is 1 in 37.

Berlin. From 1747 to 1755, the annual mortality of Berlin was 1 in 28. Between 1756 and 1799, it improved to 1 in $29\frac{1}{11}$. Here the beneficial change was retarded by the ravages, the losses, the disappointments of war, and, from 1802 to 1806, it had retrograded to 1 in 27; but from 1816 to 1822, a period of exultation and tranquillity to the Prussians, the value of life took a remarkable leap, and the annual deaths fell to less than 1 in 34.

Vienna. In the middle of the last century, the mortality of Vienna was 1 in 20, and it has not improved in proportion as other cities of Europe. According to the most recent calculations, it is, even now, as 1 in $22\frac{1}{2}$. Among 10,530 deaths, scarcely 38 persons are found to have attained the age of 90. The spirit of excessive regulation, the dread of novelty, the restrictions imposed on the medical profession, and political causes which need not be enumerated, appear to have retarded the natural progress of this city. The overweening paternity of the government interferes with the trivial concerns of the citizens, in the same manner in which an arbitrary and untaught father sometimes restrains the useful impulses of his children, while he permits an easy vent to their baser propensities.

Prague, the capital of Bohemia, has only one-third the population of Vienna, and is much healthier. The superior longevity of the Jews is strongly marked in this city. One death is annually observed among 26 of the Israelites, and 1 in $22\frac{1}{2}$ among the Christians. Instances of considerable longevity, especially among the women, are not rare. Contrary to the usual observation, longevity is confined to poverty and married life. According to an average of several years, no nobleman, no wealthy person, no bachelor, and no unmarried woman, has passed the age of 95. This is an interesting fact, but it is an extreme and

an insulated one, and does not militate against the general conservative tendency of prosperity, which a variety of evidence seems to establish.

Palermo. Mortality is here 1 in 31. January, October, and November, are the most fatal months; April, May, and June, the most healthy.

Leghorn. The average annual mortality here is 1 in 35. Among the Protestants and Jews, it is only 1 in 48, which is attributed to their greater affluence.

Rome. From a recently discovered fragment of Cicero (*De Republica*), an intimation is conveyed that the neighbourhood of Rome has been always unhealthy. Speaking of the choice of situation made by Romulus, he observes—*locum delegit in regione pestilente salubrem.* The population appears to have been gradually decreasing till the last peace, which has greatly revived it. In 1800, there were 150,000 souls; in 1810, only 123,000. Within a few years, it has gained 10,000. The annual mortality is about 1 in 25. There can be little doubt that the force of the aguish disposition of Rome might be considerably weakened by steady and well-directed efforts, supported by a proportionate capital; but it is to be feared that such a combination of circumstances will not readily meet at Rome. In 1816, 17 out of the 22 French students were attacked with intermittent fevers. The Villa Medici, in which they reside, was formerly healthy; but water, brought at a great expense, to embellish the garden, had been suffered to stagnate there.

Naples. The annual mortality here is 1 in 23; a fact that one would not have expected in such a delightful situation, compared with pestilential Rome, where the mortality is less. The population of Naples is nearly three times that of the ancient mistress of the world.

Brussels. The average mortality is very great, being 1 in 26.

Amsterdam. The population of this once great city is decreased, in consequence of declining commerce and political changes. And it is not a little curious, as well as melancholy, to observe that its mortality has increased with the progress of decay. In 1777, the ratio of mortality was 1 in 27—a period when Amsterdam was one of the healthiest as well as one of the most flourishing cities of Europe. The deaths have now increased to 1 in 24, and Amsterdam is one of the least healthy as well as least prosperous seaports of Europe. A decree was some time back issued, that after the 1st of January, 1829, no burials shall be permitted in towns or churches throughout North Holland.

Stockholm. Drunkenness appears here, as at Berlin, to produce a large share of the mortality. In a recent year, this city exhibited a singular instance of an excess of 1439 more deaths than births—a symptom which it is painful to observe in a brave and industrious people. This disproportion existed particularly amongst the garrison, and is ascribed to the immoderate use of brandy.

The Editor of the present work fully coincides in the opinion here expressed by the intelligent writer of this article. Spirituous liquors have been the fruitful source of bodily, as well as moral disease in every country in which the government has so far forgot its duty, as to pander to the vices of the people, for the mercenary consideration of a slight increase of revenue. In America, where this degrading vice was once so prevalent, spirituous liquors are now but little seen, and in their navy, a service which was formerly considered as the very "hot-bed of drunkenness," the habitual use of spirits is rapidly passing away. Our trans-atlantic brethren have accomplished this moral wonder mainly by the aid of *temperance societies*, and we shall certainly, under that head, point out the mechanism of those useful institutions.

The medical police of large cities deserves particular attention, because the health of multitudes depends upon the care which is taken by the magistrates to remove the causes of disease which originate in a great population. Knowledge of this branch of medical science can be obtained only by attentive observation, and the study of the different health-regulations of large cities under governments which have paid particular attention to it. See CLIMATE.

CITRIC ACID. This acid exists in variable proportions in the lemon, orange, and the red acid fruits. This acid is white, crystallizes in rhomboidal prisms, unalterable in the air, inodorous, of a very acid taste. Specific gravity, 1.034 According to Messrs. Gay-Lussac and Thénard, it is composed of carbon, 33.81, oxygen, 59,859, and hydrogen, 6.330. Heated, it is decomposed, and is partly changed into a new acid, called *pyro-citric*. It is very soluble in boiling water, and in three-fourths of its weight of cold water. Alcohol dissolves a smaller proportion. The aqueous solution, concentrated in a small degree, is easily altered on exposure to the air. It is obtained by saturating the lemon-juice with pulverized chalk, and treating the insoluble citrate which is formed, by diluted sulphuric acid. It is employed instead of lemon-juice for making lemonade, and it acts then like the other refrigerant medicines. In large doses, and concentrated, it might produce serious accidents, on account of its caustic action.

CLARET. See WINES.

CLARICHORD, or CLAVICHORD; a keyed instrument, now out of use, somewhat in the form of a spinet, and the strings of which are supported by five bridges. One distinction in the clarichord is, that the strings are covered with pieces of cloth, which render the sound sweeter, and at the same time deaden it so as to prevent its being heard at any considerable distance. On this account, it was formerly much used by the nuns, who could practise on it without disturbing the dormitory. It is sometimes called the *dumb spinet*.

CLARIFICATION, or the separation of the insoluble particles that prevent a liquid from being transparent, may be performed by *depuration, filtration*, or *coagulation*. In the first of these operations, the liquid is permitted to subside, without being in the least disturbed, until all the particles which were in suspension are precipitated; it is then decanted. This mode of clarification can only be used when the substance on which we operate is in a large quantity, or is of a nature not to be altered during the time necessary to complete this operation, and finally when its specific gravity is less than that of the particles which render it turbid. *Filtration* is a process by which a liquid is strained through a body, the interstices of which are small enough to stop the solid particles contained in it. Filters of wool, linen, paper, powdered glass, sand, or charcoal, may be used, according as the liquid is more or less dense, or of a nature to operate upon any one of these bodies. Finally, clarification by *coagulation* is per-

formed with the assistance of albumen contained in the liquid, or some is added to it for this purpose, which, by the action of caloric, of acids, &c. becomes solid, forms a mass, and precipitates the extraneous substances. The white of eggs is generally used for this purpose.

CLARINET. A wind-instrument of the reed kind, the scale of which, though it includes every semitone within its extremes, is virtually defective. Its lowest note is E below the F cliff, from which it is capable, in the hands of good performers, of ascending more than three octaves. Its powers, through this compass, are not every where equal; the player, therefore, has not a free choice in his keys, being generally confined to those of C and F, which indeed are the only keys in which the clarinet is heard to advantage. The music for this instrument is therefore usually written in those keys. There are, however, B flat clarinets, A clarinets, D clarinets, B clarinets, and G clarinets: the three latter are scarcely ever used in England.

CLAVICHORD. See CLARICHORD.

CLAVICIMBALUM; the name originally given to the harpsichord.

CLAY is a mixture of decomposed minerals, and hence it is by no means uniform in its composition. Several varieties soften in water, and allow themselves to be kneaded and formed into moulds—a property by which they are fitted for the use so commonly made of them. Some are easily fusible, others refractory; some acquire particular tints, others lose their colour and become white when exposed to a strong heat; upon all of which properties their applicability depends. They occur in beds near the surface of the earth, or covered by the soil, in the formations of brown and black coal. In the latter situation they often contain the remains of vegetables, and are called *slate clay*, which is intimately related to bituminous shale and alum-earth.

Alumine is the basis of all clays, and imparts to them their predominating characters. It is mixed with very variable proportions of silex, magnesia, lime, and oxide of iron. The varieties of clay are of various important applications in pottery, in manufacturing stone-ware and porcelain, in constructing furnaces for metallurgic operations, &c.—Some of the principal varieties are *indurated clay*, or *clay stone*, which is clay in its highest state of induration. It is soft, but not easily diffused in water, and does not form with it a ductile paste.

Porcelain clay, so named from the use to which it is applied, is white, with occasional shades of yellow and gray. It is dull and opaque; feels soft; in water it falls to powder, and when kneaded, it forms a ductile paste. It is in general infusible by any heat that can be raised. It consists essentially of silex and alumine; that of Cornwall contains 60 parts of alumine with 20 of silex.

Potter's clay and *pipe clay* are similar, but less pure, generally of a yellowish or grayish colour, from the presence of iron.—*Loam* is the same substance mixed with sand, oxide of iron, and various other foreign ingredients.—The *boles*, which are of a red or yellow colour, are of a similar composition, and appear to owe their colours to oxide of iron. They are distinguished by their conchoidal fracture.—The *ochres* are similar to the boles, containing only more oxide of iron.

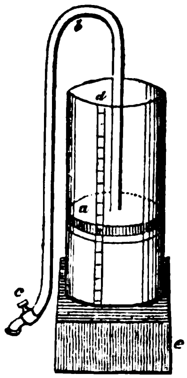
Fuller's earth has an earthy fracture, sometimes slaty, is dull and opaque. In water it falls to powder, without forming a ductile paste. It is used to remove grease from cloth.

Tripoli is found loose or indurated; its fracture is earthy; it feels harsh and dry; does not adhere to the tongue. It is used for polishing the metals and glass. The clays are too generally distributed to require the enumeration of their localities.

CLEPSYDRA; an instrument used in the measurement of time. In the earliest water-clocks, the indication of time was effected by marks corresponding to either the diminution of the fluid in the containing vessel, during the time of emptying, or to the increase of the fluid in the receiving vessel duriug its time of filling; but it was soon found that the escape of the water was much more rapid out of the containing vessel when it was full, than when it was nearly empty, owing to the difference in the pressure at different heights from the surface. This irregularity in the dropping, presented an obstacle which required much ingenuity to correct. Ctesibius of Alexandria, who flourished more than two hundred years prior to the Christian era, spent much time in devising various contrivances for perfecting the instrument. One serious objection to its practical application at that period arose from the daily inequality of the Egyptian hours. As one-twelfth part of the time that passed from sun-setting to sunrise was called an hour of the night, not only did the hours of day differ from the hours of night, but from one another, at all times, except at the vernal and autumnal equinoxes; hence, it became necessary, either to make the water fall irregularly into a receiving vessel, with equi-distant hour-marks, or to have varying hour-marks for a regular efflux; the first of these methods was thus effected. A conical hollow vessel was inverted, or placed like a funnel in a frame, there being a very small aperture at the apex of the cone, and another solid cone, every way similar as to dimensions, was plunged into the hollow one, when filled with water to a greater or smaller depth, accordingly as the efflux was wanted to be more or less rapid, and then adjusting marks, corresponding to every day and night in the year, were put on a long stem, inserted in the broad end of the solid cone, and kept in its position by the frame, to show how much the inner cone was to be depressed or elevated, to accelerate or retard the issue of the fluid for the corresponding time. A waste pipe, connected with the top of the conical vessel, carried off the superfluous water; hence the constant influx of water preserved an unvarying height at the surface from the aperture, which aperture was varied at pleasure, by the elevation or depression of the inner cone; if now we suppose the subjacent vessel to be a cube, cylinder, or any other regular figure, and equidistant hour-marks to be properly made on its side, the surface of the water, or an index borne by it on a piece of cork, would, as it rose, indicate the hours corresponding to those marks.

As an improvement, or rather appendage to this construction of the clepsydra, a bar, with rackwork at the upper end, was made to float on the surface of the lower vessel, so that as it rose in the vessel, the bar turned a small wheel, fixed to the upper part of the frame by a cock, on the arbor of which wheel a hand was put, which revolved, and indicated the hours on a fixed dial-plate.

We may now turn to a more simple form of the clepsydra. Its arrangement is shown in the engraving.



It consists of a cylinder of glass furnished with a float, *a*, supporting a syphon, *b*. If we suppose the water gradually discharged from a small stop-cock at the end of the syphon, the passage of the time will be indicated by the descent of the float past the graduated line, *d*. It will be obvious that whatever situation the float may be placed in, the pressure of the fluid in the syphon is the same, and as such it will pass through equal distances in equal times. The Editor presented an instrument of this description to the National Repository, some years ago.

Cliffs, or Claves; certain indicial characters placed at the beginning of the several staves in a composition, to determine the local names of the notes, and the sounds in the great scale which they are intended to represent. The three cliffs now in use, viz., the F, or bass cliff, the C, or tenor cliff, and the G, or treble cliff, by the several situations given them on the stave, furnish us with the means of expressing all the notes within the usual compass of execution, both in vocal and instrumental music, without a confused addition of leger lines, either above or beneath the stave.

Climate. The ancients denoted by this name the spaces between the imaginary circles, parallel to the equator, drawn in such a manner over the surface of the earth, that the longest day in each circle is half an hour longer than in the preceding. According to this division, there were twenty-four climates from the equator, where the longest day is 12 hours, to the polar circle, where it is 24 hours. From the polar circle, the longest day increases so rapidly, that only one degree nearer the pole it is a month long. The *frigid zones*, so called, that is, the regions extending from the northern and southern polar circles to the corresponding poles, some geographers have divided again into six climates. We have learned from a more accurate acquaintance with different countries, that heat or cold depends not merely on geographical latitude, but that local causes also produce great variations from the general rule, by which a region lying near the equator should always be warmer than one remote from it. By the word *climate*, therefore, we understand the character of the weather peculiar to every country, as respects heat and cold, humidity and dryness, fertility, and the alternation of the seasons. The nature of a climate is different according to the different causes which affect it, and the observations hitherto made have led, as yet, to no definite result. In general, however, geographical latitude is the principal circumstance to be taken into view in considering the climate of a country. The highest degree of heat is found under the equator, and the lowest, or the greatest degree of cold, under the poles. The temperature of the intermediate regions is various, according to their position and local circumstances.

Under the line, the heat is not uniform. In the sandy deserts of Africa, particularly on the western coast, also in Arabia and India, it is excessive. In the mountainous regions of South America, on the contrary, it is very moderate. The greatest heat in Africa is estimated at 70° of Réaumur, which is very hot. The greatest degree of cold at the poles cannot be determined, because no one has ever penetrated to them. The greatest altitude of the sun at noon, and the time of its continuance above the horizon, depends altogether on the latitude. Without regard to local circumstances, a country is warmer in proportion as the sun's altitude is greater and the day longer. The elevation of any region above the surface of the sea has likewise an important influence on the climate. But the nature of the surface is not to be disregarded. The heat increases as the soil becomes cultivated. Thus, for the last thousand years, Germany has been growing gradually warmer by the destruction of forests, the draining of lakes, and the drying up of bogs and marshes. A similar consequence of cultivation seems to be apparent in the cultivated parts of North America, particularly in the Atlantic states. The mass of minerals, which composes the highest layer of a country, has, without doubt, an influence on its temperature. Barren sands admit of a much more intense heat than loam. Meadow lands are not so warm in summer as the bare ground. The winds to which a country is most exposed by its situation, have a great influence on the climate. If north and east winds blow frequently in any region, it will be colder, the latitude being the same, than another, which is often swept by milder breezes from the south and west. The influence of the wind on the temperature of a country is very apparent in regions on the sea-coast. The difference in the extremes of temperature is least within the tropics. The heat, which would be intolerable when the sun is in the zenith, is mitigated by the rainy season, which then commences. When the sun returns to the opposite half of the torrid zone, so that its rays become less vertical, the weather is delightful. Lima and Quito, in Peru, have the finest climate of any part of the earth. The variations in temperature are greater in the temperate zones, and increase as you approach the polar circles. The heat of the higher latitudes, especially about 59° and 60°, amounts in July to 75° or 80° of Fahrenheit, and is greater than that of countries 10° nearer the equator. In Greenland, the heat in summer is so great that it melts the pitch on the vessels. At Tornea, in Lapland, where the sun's rays fall as obliquely, at the summer solstice, as they do in Germany at the equinox, the heat is sometimes equal to that of the torrid zone, because the sun is almost always above the horizon.

Under the poles, the climate is perhaps the most uniform. A greater degree of cold than any we are accustomed to, seems to reign there perpetually. Even in midsummer, when the sun does not go down for a long time (at the poles not for six months), the ice never thaws. The immense masses of it which surround the poles, feel no sensible effect from the oblique and feeble beams of the sun, and seem to increase in magnitude every year. This is very remarkable; for there is the most undoubted evidence that these now deserted countries were, in former ages, inhabited. But, within a few years, large portions of this continent (if we may so call it) of ice have separated, and floated down to southern seas. This led our government to adopt the project of penetrating to the north pole. Captains Ross and

Parry have successively sailed as far as possible into the arctic ocean.

From the general division of America into lofty mountainous *plateaus* and very low plains, there results a contrast between two climates, which, although of an extremely different nature, are in almost immediate proximity. Peru, the valley of Quito, and the city of Mexico, though situated between the tropics, owe to their elevation the general temperature of spring. They behold the *paramos*, or mountain ridges, covered with snow, which continues upon some of the summits almost the whole year, while, at the distance of a few leagues, an intense and often sickly degree of heat suffocates the inhabitants of the ports of Vera Cruz and of Guayaquil. These two climates produce each a different system of vegetation. The flora of the torrid zone forms a border to the fields and groves of Europe. Such a remarkable proximity as this cannot fail of frequently occasioning sudden changes, by the displacement of these two masses of air, so differently constituted—a general inconvenience experienced over the whole of America. Every where, however, this continent is subject to a lower degree of heat than the same latitudes in the eastern portion of the earth. Its elevation alone explains this fact, as far as regards the mountainous region; but why, it may be asked, is the same thing true of the low tracts of the country? To this the great observer, Alexander Humboldt, in his *Tableaux de la Nature*, makes the following reply: "The comparative narrowness of this continent; its elongation towards the icy poles; the ocean, whose unbroken surface is swept by the trade winds; the currents of extremely cold water which flow from the straits of Magellan to Peru; the numerous chains of mountains, abounding in the sources of rivers, and whose summits, covered with snow, rise far above the region of the clouds; the great number of immense rivers, that after innumerable curves always tend to the most distant shores; deserts, but not of sand, and consequently less susceptible of being impregnated with heat; impenetrable forests that spread over the plains of the equator, abounding in rivers, and which, in those parts of the country that are the farthest distant from mountains, and from the ocean, give rise to enormous masses of water, which are either attracted by them, or are formed during the act of vegetation,—all these causes produce, in the lower parts of America, a climate which, from its coolness and humidity, is singularly contrasted with that of Africa. To these causes alone must we ascribe that abundant vegetation, so vigorous and so rich in juices, and that thick and umbrageous foliage, which constitute the characteristic features of the new continent." To these remarks Malte-Brun adds, "Assuming this explanation as sufficient for South America and Mexico, we shall add, with regard to North America, that it scarcely extends any distance into the torrid zone, but, on the contrary, stretches, in all probability, very far into the frigid zone; and, unless the revived hope of a north-west passage be confirmed, may perhaps reach and surround the pole itself. Accordingly, the column of frozen air attached to this continent, is no where counterbalanced by a column of equatorial air. From this results an extension of the polar climate, to the very confines of the tropics; and hence winter and summer struggle for the ascendency, and the seasons change with astonishing rapidity. From all this, however, New Albion and New California are happily exempt; for, being placed beyond the reach of freezing winds, they enjoy a temperature analogous to their latitude."

A complete system of meteorology, so far as the medical properties of climates, with regard to temperature only, are concerned, presents almost as great difficulties as a complete theory of the nature and cure of diseases. In this, as in many other departments of medical knowledge, we perpetually find a multiplicity of accounts, apparently well attested, but totally at variance with each other, which render it desirable to appeal to some more satisfactory testimonials than the results of common and superficial observation; while the evidence which would be required for forming useful conclusions upon safe and scientific grounds, although in this case completely within the scope of the human faculties, is still such as to require, for its production, a combination of perseverance and accuracy, which has certainly never yet existed, and which probably can scarcely ever be expected to be found in a sufficient number of collateral observers. Any voluminous work on the subject, whether systematic or empirical, must unavoidably contain much useless, and some erroneous matter; and a short statement of a few facts, which appear to be tolerably well ascertained, first, respecting the physical character; and, secondly, respecting the medical effects of the principal climates which deserve our notice, is all that it will be possible to attempt in the present article.

The simple indications of a thermometer, however accurately they may be observed in the most unexceptionable exposure, by no means afford a correct test of the temperature as it affects the human system; nor is it possible to express the modifications produced by wind or moisture, even supposing them to be easily known, by any numerical measure which shall be applicable to every relative situation of the individual. It is known that an atmosphere at 65°, with a thick fog, and a little wind from N. E., may appear, to a person taking moderate exercise, most oppressively sultry, although a person sitting still long might have felt the same air uncomfortably cold. Moisture must make both heat and cold more sensible; the one, by diminishing perspiration; the other, by increasing the conducting power of air. Wind is doubly concerned in affecting the properties of a climate: first, as the great cause of preventing a general accumulation of heat over considerable tracts of country; and secondly, as having a similar effect with respect to the immediate neighbourhood of the person; and its operation is as generally perceptible in the latter way, where we have no precise mode of estimating its magnitude, as in the former, where it is correctly indicated by a thermometer sufficiently exposed: although in fact, the most shaded fixed thermometer may often be observed to indicate a temperature many degrees higher than that of the breeze which is circulating in the neighbouring country. Still more commonly by the sea-side the wind exhibits the temperature of the water over which it has blown. At Worthing, it is seldom above 64° in the hottest weather, although the sea, when the tide flows in at noon, over the heated expanse of sand, is sometimes raised to 78°, where it is several feet deep.

To the inhabitants of these islands, the most important properties of the climates of other countries

are those which render them more or less fit for the residence of persons liable to catarrhal, or consumptive affections. Hence, warmth and equability of temperature, especially in the winter months, are the first objects of our inquiry in the theoretical comparison of climates. Moisture is supposed by some to be favourable; by others, to be unfavourable to such persons: it may, therefore, be safely neglected, except as tending to increase the evils depending on a want of equability of temperature. The effluvia of moist ground are sufficiently well known as the causes of paludal fevers; farther than this they require no particular investigation. Nor can we attempt to assign any reason for peculiarities which render some situations preferable to others, for some individuals only labouring under a given disease, as asthma, which is sometimes induced by the atmosphere of cities, and sometimes of the country; and which is occasionally mitigated by a residence in places having no marked distinctions from such as are less favourable to it, as Kensington, and perhaps some others.

In the hotter seasons there are few diseases, and few constitutions which would require a climate milder than our own: in the colder, an increase of the facility of circulation which heat appears to afford, may often be beneficial; partly perhaps, as exciting perspiration, and partly as preventing too great a congestion of blood in the internal parts of the body. The mean temperature of the six winter months is therefore the first point of comparison that requires our attention; and such a comparison may easily be derived from the registers which are usually kept in circumstances nearly similar.

From October to March.

London, R. S. 1790—4	43.5°
Edinburgh	40.4
Dawlish, Sir W. W. M. S. 1794. (Lond. 44.1°)	45.3
Ilfracombe, without doubt incorrect	(55)
Paris	41.2
Lisbon	55.5
Malta, Domeier	63
Madeira, Gourlay, (S. W. aspect, M.)	63
Bermudas, M. S. R. S. 1790	68
Jamaica, Botanic Garden at Kingston, Clarke, Dunc. med. comm. vii. 369	74.5

From November to March.

London, 1808-9	42.6°
Penzance, 1808-9, Stirling at 10, or about 1° above the mean	48.1

From January to March.

London, 1808-9	43.1°	(Jan. 37.9°)	
Glasgow, 1809, Stirling, at 10	40.3	33.1	
Penzance, 1809, Stirling at 10	48.5	46.7	(Dec. 43·7°)
London, 1790-4, 8, or 7 and 2	41.6	39.1	
Sidmouth, 1800, M. S. R. S. 8 and 2	41.7	(42.3)	

February and March.

London, 1803, 7 and 2	41.5°
Clifton, 1803, 8 and 2, Carrick	42.5

From October to December.

London, 1811, mean of extremes in each month	47.0°
Sidmouth, 1811, Clarke	45.7

From December to February.

London	39.7°
Edinburgh	36.7
Paris	36.8

It appears from this comparison that none of the situations here enumerated north of Lisbon, except Penzance, has any material advantage over London in the mildness of its winter. The best parts of Devonshire seem to be about a degree and a half warmer; Torbay, however, may perhaps be a little milder than this. The account which was kept at Ilfracombe, must have been taken from a thermometer in a confined, or a sunny situation. But Penzance may be fairly considered as having a temperature 4½° higher than London in the coldest months; nor is the journal here employed the only one which allots such a superiority to the climate of this extremity of our island. It is remarkable that the temperature of the three coldest months is the same at Paris as at Edinburgh, being in both these cities about three degrees lower than in London. There are probably particular spots on the coast of Hampshire or Sussex, which, from their sheltered situation, must be considerably less subject to the effect of the northern and eastern winds than most other parts of the island; and Hastings, or its neighbourhood, may perhaps be reckoned among the most eligible of these; but the farther we go up the channel, the more remote we become from the mild gales of the Atlantic, while the prevalent south-westerly winds, in passing over a considerable part of the continent, must have lost much of their warmth. It is scarcely necessary to observe, that both Malta and Madeira present, numerically, a mean temperature for the winter months as favourable for an invalid as can possibly be desired.

Equability of temperature is a second quality, of no small importance, as tending to diminish the chance of incurring, or aggravating pulmonary diseases, by repeatedly taking cold. When indeed the temperature is much below 60°, the most material changes are those which occur upon going from the house into the open air; so that a cold climate becomes, in some degree, of necessity a changeable one also. The regularity of this change, and the power of avoiding its effects by additional clothing, as well as of obviating them in some measure by exercise, contribute however to lesson its influence: and it does not, therefore, altogether supersede the effects of that changeableness which consists in a great extent of variation of the temperature of two successive days, or of different hours in the course of the same day. The simplest, and perhaps the best mode of appreciating the effect of the extent of such a variation in deteriorating a climate, is to observe for each month, the greatest variation at the same hour, in any two successive days within its duration. The mean variation of successive days may also be computed, in order to assist in the comparison; and the mean diurnal range, or the space through which the surface of the mercury moves, in ascending or descending, throughout the day and night, will give a collateral estimate of a similar nature. The best practical mode of deducing this range from the observations is, to find separately the mean of the heights for the morning and afternoon, and to double their difference. Where none of these principles can be obtained, the extreme variation of each

month will afford a character not altogether unimportant.

Mean of the greatest Variations of successive Days in each Month, for the Winter Months.

London, 1794 (greatest of all 15°)	10.7°
Knightsbridge, Read, 1790-1 (greatest 23°)	16.3
Dawlish, 1794 (greatest 13½°)	10.7
Lisbon, 1788 (greatest 11°)	8.7
Bermudas, 1790 (greatest 13°)	9.0
Montreal, 1778	4.0
Penzance, 1808-9, November to March, (gr. 10°)	9.2
Sidmouth, 1800, January to March, (gr. 16°)	10.9
Gravesend, 1787, January	13.0
Ashover, Derbyshire, 1805, January	13.5
London, 1790—4, 6mo	3.62
London, 1794	3.51
Knightsbridge, 1790-1	5.45
Dawlish, 1794	3.68
Lisbon, 1788	2.70
Bermudas, 1789, about	3.00
Montreal, 1778	1.32
Penzance, 1808-9, November to March	2.80
Sidmouth, 1800, January to March	3.32
Clifton, 1808, February and March	3.55
Gravesend, 1787, January	4.15
Ashover, 1805, January	3.33
Minehead, 1782, January	4.00

Mean diurnal Range for the Winter Months.

London, 1790—4, 6mo	13.0°
Sidmouth, 1800, January to March	10.0
Clifton, 1808, February and March (Lond. 16.2°)	11.4

New Monthly Variation for the Winter Months.

London, 1793—6, 6mo	25.9°
Madeira, 1793—6, 6mo.	12.6
Sidmouth, 1811, January to March	34.
Clifton, 1803, February and March (Lond. 36°.)	31.

It does not appear that Devonshire possesses any decided advantages over London with respect to equability of climate, if we judge of the climate of London from the observations made at the apartments of the Royal Society only; but in so central a situation, the change must be rendered much less sensible by the effect of the surrounding buildings; and they appear to be considerably greater at Gravesend, and greater still at Knightsbridge In this respect, too, Penzance retains its superiority even over Devonshire. Lisbon seems to have a less variable temperature than any part of Great Britain; and in Madeira, to judge by the monthly variation only, the advantage in this respect appears to be still greater; on this account it is much resorted to.

The greatest possible equability of temperature seems, however, to be obtained in a sea voyage to a warm climate, in which the variation seldom amounts to half as much as in the most favourable situation on shore, even on a small island; and in pulmonary cases, the motion of a ship would probably in general be rather beneficial than otherwise, while the fatigue of travelling in bad roads, and the danger of sleeping in damp beds, present an alternative by no means favourable to a journey by land.

The direction of the wind alone can seldom have an immediate effect on the salubrity of the climate, except by variously modifying its temperature, according to the seas or countries over which it blows. There is a method of computing the mean direction of the wind, which does not appear to have been hitherto adopted, but which affords a very simple and intelligible result, although somewhat laborious if extensively applied. It consists in finding the bearing and distance of a point, to which a light body would be carried by the wind in the course of the year, supposing the velocity to be constant, when its variations have not been ascertained by observation. It is obvious that the bearing of such a point will show at once the mean direction of the prevalent winds; and its distance, compared with the effect of a constant wind for the same time, as a unit, will indicate the degree in which those winds have prevailed.

Prevalence of Winds.

London, 1790-4	W. 9° S.	.234
London, 1794,	W. 33° S.	.188
Dawlish, 1794,	W. 6° S.	.466
Lisbon, 1788,	N. 1° W.	.315

According to this comparison, it appears that the mean direction of the wind in Devonshire is somewhat more westerly than in London; and that the degree in which such westerly winds predominate, is more than twice as great as in London; or, if we convert the measure into days, that the predominance amounted in 1794, to sixty-eight days for London, of a wind nearly west-south-west, and to one hundred and seventy days for Dawlish, of a wind a little to the south of west.

The variations of the climate of the same place, with respect to mean temperature, are easily collected from the usual meteorological computations. Dr. Heberden has very successfully combated the common opinion respecting the superior salubrity of cold winters; it appears, however, that the winter which he particularly observed was more variable, as well as colder, than usual. Mr. Kirwan has attempted to account for the greater frequency of colds, which he supposes to occur in spring and in autumn, by the greater variability of the temperature at those seasons: but both the fact and the explanation are very questionable; for in reality the variations of temperature, if estimated by the total range of the thermometer within the twenty-four hours, are almost uniformly greatest in the hottest weather. In London, the greatest variations of successive days at the same hours in the morning are greatest in winter; in the afternoon, in summer; and although the latter are a little greater in April than in some of the succeeding months, the difference is by no means considerable.

Of the empirical evidence which may be collected respecting the medical effects of different climates, the most authentic is perhaps that which is derived from well regulated bills of mortality; since these documents ought to afford us a tolerable criterion of the general healthiness or unhealthiness of a place. Thus, in Stockholm, the annual deaths amount to $\frac{1}{19}$ of the population, in London to $\frac{1}{21}$, in the Pays de Vaud to $\frac{1}{45}$, and in some villages in different parts of Great Britain to $\frac{1}{80}$ only, we cannot hesitate to consider a residence in the country as generally more healthy than in a metropolis similar to either of those cities; although it cannot fairly be concluded that the healthiness is precisely in the proportion which might be inferred from this composition, until we have considered how far the effect of emigration to a great town may influence the apparent mortality.

After the age of eight or ten, the probable duration of life may be estimated with sufficient accuracy, as Demoivre has very ingeniously shown, by assuming that, of a certain number of persons born together, one will die annually until the whole number is become extinct; and it is well known, that this number may in common cases be eighty-six; so that at any given age, for instance, thirty-six, we may find the probable duration of life by deducting it from eighty-six, and halving the remainder, which will give us twenty-five for the estimate required; and if this law were universally true from the time of birth, it is easy to show that the mortality in a metropolis would always be increased by the accession of settlers; so that if, for example, the whole population were supplied by settlers at twenty, and all children were sent to a neighbouring village to be educated, the mortality of the town, instead of $\frac{1}{43}$, would become $1 : (43-10) = \frac{1}{33}$, and that of the village would be $1 : (86-10) = \frac{1}{76}$; and that any partial changes of a similar nature would cause a smaller alteration of the apparent salubrity, in proportion to their extent. But the mortality during infancy is actually much greater than is assumed in the simple hypothesis of Demoivre; and from this circumstance, as well as from the frequent return of aged persons into the country, Dr. Price has inferred that emigration in general has no tendency to increase the mortality of cities. In reality, the question depends altogether upon the mortality which might be supposed to take place within the first year, which is often estimated at one-third of the births; but nothing like this can well be expected to occur at any tolerably healthy place in the country; and on the whole it does not appear that Dr. Price's observations can by any means be admitted as conclusive. With respect to the evidence afforded by the prevalence of diseases, it has been observed by Dr. Gregory, that removing from a colder to a warmer climate may be beneficial, even in those diseases to which the inhabitants of the warmer climate are subject; but if they appeared to be equally or more subject to any disease than the inhabitants of the colder, there would surely be little encouragement for the change: for instance, in a person supposed to be liable to diseases of the liver, it would surely be injudicious to undertake a voyage to a hot climate, with a view of avoiding the chance of taking cold, since the well-known frequency of hepatitis in such climates, would much more than counterbalance any prospect of advantage from the change.

The frequency of consumptions is decidedly greater in cold than in hot climates, but not by any means in exact proportion to the depression of the mean temperature. The principal situations that require to be compared with the metropolis as a standard, are the south of England, south of Europe, the islands of the Mediterranean, Madeira, and the West Indies.

There do not appear to be any precise accounts of the proportionate mortality from consumption at any place upon the southern coasts of this island, on a scale sufficiently extensive for the comparison; but there is abundant reason to think that such a report would be greatly in favour of the salubrity of these coasts, more so indeed than any conclusions that we should be at all authorized to form from such thermometrical observations as have hitherto been compared. A greater number of registers is still wanting to obtain sufficient evidence for the inquiry: and it would be desirable that some journal should be kept at one of the Scilly islands, as a situation fully exposed to the influence of the sea air; for there can be little doubt that, for equability of temperature, a very small island must have great advantages above every other situation on shore. But in the present state of our knowledge on this subject, although we are fully justified in recommending a residence in Devonshire or Cornwall as advisable in a certain stage of consumption, it does not appear that any meteorological observation will authorize us to represent the advantages to be gained by such a residence, as by any means equivalent to those which may be found in remoter situations; nor that the empirical testimony derived from accounts of the comparative prevalence of the disease, is at all so clear, or so firmly established, as to make up for the want of evidence of a great and decided superiority of the climate.

In the south of Europe, the situations which have been most frequented are Lisbon, or some other part of the peninsula, the neighbourhood of Montpelier, and different parts of Italy. In Spain, and probably in Portugal, consumption is said to be not common, but by no means wholly unknown; and whether from accident, or from causes which are likely to have a constant operation, the climate of Portugal has certainly failed, in a number of instances, of producing any material benefit, where there has been apparently a very fair chance for the patient's recovery. With respect to the south of France, it is perhaps sufficient to remark, that the general proportion of deaths from consumption at Marseilles, is fully as great as the greatest which has been observed in London, where, according to Dr. Heberden's remark, its prevalence has of late years been so much increased. In Italy, the disease appears to be decidedly less frequent; and there is no reason to doubt but that in the southern parts of that country there may be situations approaching in their climates to those of the neighbouring islands.

It is, however, highly probable that some of these islands possess very considerable advantages over almost every part of the continent which surrounds them, at least as far as we can judge by their affording a climate of that description which seems to be the most desirable; for actual experience will not allow us to be too confident of obtaining success, even from a residence in these. Dr. Domeier informs us, in his very interesting account of the island of Malta, that the thermometer seldom varies here more than 6° in the twenty-four hours, or stands below 51°, even in the depth of winter; while in Lisbon he has seen ice, and both ice and snow in Naples; besides that, in these two cities the difference between day and night often amounts to 20°. If an invalid leaves England in the middle of August, the voyage lasts about a month, and is often of itself highly beneficial, so that he arrives at Malta in time to be fully prepared to be farther benefited by the mild winter. It appears, however, from the more particular account which Dr. Domeier elsewhere gives of the temperature, that it continues throughout October rather higher than is altogether desirable, being seldom below 70° throughout that month; and in a country where there is scarcely any visible foliage, walls occupying universally the place of hedges, this cannot be a matter of perfect indifference.

In Madeira, though the thermometer attached to a building is seldom found below 54°, there are frequently cold winds, snow, or more commonly something intermediate between snow and hail, often falling on the mountains at the height of one thousand feet above the sea, and at still greater elevations sometimes lying undissolved till July: and this imperfect kind of hail falls occasionally even on the low grounds. The island is probably a more agreeable residence than Malta; but it seems very doubtful whether it possesses any determinate advantage over it with respect to climate; and it is not impossible, that some other islands in its neighbourhood may afford a greater equability of temperature. We have, however, a more established experience of its beneficial effects in pulmonary diseases than of almost any other situation. Dr. Adams says, that "in cases of tubercular or scrofulous consumption, if the patient does not saunter away his time after you have advised him to leave England, we can with certainty promise a cure." (*Med. Phy. Journ.* April, 1800.) The true English consumption he thinks is not to be found in Madeira, while the catarrhal affection, which somewhat resembles it, though without purulent expectoration, is not uncommon, and may be fatal if neglected or improperly treated. Dr. Gourlay agrees with Dr. Adams, in his report of the general benefit derived from the climate of Madeira, by consumptive persons going to it from colder countries to pass the winter in the island, and of the frequency of catarrhal affections among the inhabitants; but he strongly insists that genuine consumption is also very common and very fatal. There can however be little doubt, from the concurrent testimony of the majority of the observers, that the climate of Madeira is extremely salubrious, and that consumptions, though they may sometimes occur, are comparatively rare.

In the West Indies, it is agreed by all authors, that consumptive affections are almost unknown, and that scrofula in all its forms is uncommon; while the inhabitants of the West Indies, coming into a colder climate, are peculiarly liable to the attacks of these diseases. Dr. Hunter, however, observes, that notwithstanding this exemption in favour of the natives of the West Indies, a residence in this climate appeared to him to be of no manner of advantage to persons who were already affected by incipient consumptions when they arrived there. We cannot doubt the accuracy of this evidence, as far as regards the facts which came immediately under Dr. Hunter's observation; they principally related to the military, who perhaps laboured under some peculiar disadvantages: but other practitioners have given much more favourable reports of the events of cases, in which they have made trial of the effect of a residence in this climate; and if we may be allowed to draw any inference from the qualities of a climate, as indicated either by the thermometer, or by its effects on the constitutions of the inhabitants, there can be little doubt that a residence in Bermudas, in a temperate and sheltered part of Jamaica, or in some other of the West India islands, together with the equable qualities of the sea air, to which the patient must be exposed during the voyage, must present every advantage towards the recovery of a consumptive person that climate alone can possibly bestow.

In other diseases, the effects of climate are perhaps less exclusively beneficial, although it appears that gouty persons often derive considerable benefit from a residence in the hottest countries, as in the East Indies, or at Ceylon in particular. Dr. Gregory seems to be persuaded that life may be lengthened, and the inconveniencies of old age retarded or mitigated, by repeated emigrations into warmer and warmer climates, after the age of fifty or sixty, according to circumstances: and he thinks that even posterity may be benefited by an emigration of this kind.

In whatever situation the residence of an invalid may be fixed, it is of no small importance that the aspect and exposure of the house which he occupies, should be selected with a view to the qualities of climate which he is desirous of obtaining. We have an illustration of the truth of this remark, in an observation recorded by Dr. Carrick, respecting the influenza of 1803. "One of the most open and exposed of the buildings on Clifton Hill is Richmond Terrace, which forms three sides of a parallelogram, fronting respectively the east, south, and west; on the east side, not one family, and scarcely an individual, escaped the complaint; while on the south side, a great majority, both of persons and families, in all other respects similarly circumstanced, escaped it entirely." Such facts as these are among the few which afford solid grounds for medical reasoning; and they deserve the more attention, as they relate to circumstances of continual occurrence, and of perpetual influence on our health and comfort; and in proportion as both the medical and the meteorological sciences become founded on a firmer basis, it cannot be doubted that their beneficial effects will be more and more experienced, as well in the preservation of health as in the treatment and cure of diseases.

Clinical Medicine teaches us to investigate at the bedside of the sick, the true nature of the disease in the phenomena presented; to note their course and termination; and to study the effects of the various modes of treatment to which they are subjected. From this mode of study we learn the character of individual cases; theoretical study being competent to make us acquainted with species only. Clinical medicine demands therefore careful observation. It is in fact synonymous with experience. What advances would medicine have made, and from how many errors would it have been saved, if public instruction had always followed this natural course, so that pupils had received none but correct impressions and distinct conceptions of the phenomena of disease, and had attained a practical knowledge of the application of those rules and precepts, which dogmatical instruction always leaves indefinite!

We are unacquainted with the method of clinical instruction in medicine which was followed by the Asclepiades, but we cannot help admiring the results of it as exhibited to us in the writings of Hippocrates, who augmented the stores of experience inherited from them by following in their steps. After his time medicine ceased to be the property of particular families, and the path of experience by which it had been rendered so valuable was soon deserted. The slow progress of anatomy and physiology, the constant study of the philosophy of Aristotle, and endless disputes respecting the nature of man, of diseases and of remedies, occupied all the attention of physicians; and the wise method of observing and describing the diseases themselves fell into disuse.

Hospitals, at their origin, served rather as means of displaying the benevolence of the early Christians than of perfecting the study of medicine. The school of Alexandria was so celebrated, according to Ammianus Marcellinus, that a careful attendance upon its lessons entitled the student to pursue the practice of medicine. Another old and very thriving although less known institution, was situated at Nisapour, in Persia; and hospitals, even before the flourishing period of the Arabians, to whom the happy idea is commonly ascribed, were united with these medical institutions. The last school, founded by the emperor Aurelian, and superintended by Greek physicians, spread the doctrines of Hippocrates through all the East. It was supported for several centuries, and in it, without doubt, Rhazes, Al-Abbas, Avicenna, and the other celebrated Arabian physicians were instructed. At the same time, the celebrated John Mesue, of Damascus, was at the head of the hospital of Bagdad. Of the mode of instruction pursued there we know nothing; but we are inclined to form no very elevated opinion of the systems of an age which was devoted to all the dreams of Arabian *polypharmacy*. In truth, medicine shared the fate of all the other natural sciences in those barbarous ages. Men were little disposed to acquire slowly and cautiously the knowledge of disease at the bedside of the sick, in the manner of the Greek physicians.

It appears probable that the foundation of universities led to a renewed attention to the study of medical science; and we find accordingly, that in Spain, even under the dominion of the Arabians, there were schools and hospitals for the instruction of young physicians at Seville, Toledo, and Cordova. But even then, clinical studies were almost wholly neglected. Instead of studying the history of diseases, the pupils occupied their time with the most unprofitable pursuits. Not much more advantageous were the journeys that were made for the same objects to Italy and France, in the 11th and 12th centuries. The schools of Paris and Montpelier were those principally resorted to; but in these, the instruction consisted simply in lectures and endless commentaries upon the most obscure subjects; and even at the close of the 15th century, when the works of the Greek physicians began to be printed, men were still busied with verbal explanations and disputes. Two centuries elapsed before physicians returned to clinical studies and instructions. Among the renovators of this mode of studying medicine may be named, in Holland, William Von Straten, Otho Heurnius, and the celebrated Sylvius, about the middle of the 17th century; and it is said that clinical instruction was given at the same period in the schools of Hamburg, Vienna, and Strasburg. Even Boerhaave, who succeeded Sylvius as clinical instructor at Leyden, in 1714, has left us no journals of daily observation of disease, but only academic discourses upon the general principles of medicine.

The influence of this celebrated school was first perceived at Edinburgh, and afterwards at Vienna —two schools which, in celebrity for clinical instruction, soon eclipsed their common mother the school of Leyden. Cullen, one of the most celebrated teachers of practical medicine at Edinburgh, was too fond of fine-spun theories upon the condition of the diseased structures of the body, and the proximate causes of disease, ever to follow an uniform method in his lectures, and to adopt the entire history of disease, as observed at the bedside, as the basis of his system. From the account of what was effected in clinical medicine in Italy, Germany, and France, in the course of the 18th century, we may discover both the constantly increasing attention to this department of knowledge, and the difficulties with which such institutions are obliged to contend.

The Vienna school, by means of the labours of Van Swieten, De Haen, and still more of Stoll and of Franck, became a model of clinical study, since public lectures were given in the hospitals, and the simplicity of Grecian medicine successfully inculcated. The practice and study of medicine, in the hospitals in France, was only an indirect mode of gaining public confidence, till the period of the general revival of science, and the erection of the French *Ecole de Santé*. In that, for the first time, clinical instruction was expressly commanded.

At the present day, every good school has its establishment for clinical medicine connected with it; that is, an hospital in which diseases can be seen and studied by those attending it. In Germany, the empyrical or experimental mode of studying medicine was early given up for the more scientific form of lectures; while in England and France, the opposite extreme took place, and students were carried, as they sometimes are still, to the bedside of the sick, before they had been properly grounded in elementary studies. In Germany there are very numerous journals which contain clinical reports of cases, as there are so many clinical institutions appropriated to particular classes of disease.

We may cite the London Hospital, which has flourished under the fostering care of Sir W. Blizard for more than half a century, as one of the most perfect in the metropolis.

The clinical school is called *ambulatory*, when the patients attend only at particular hours; and it is termed *polyclinic*, when the instructer and his pupils visit together the beds of the sick.

Clock. For many inventions which do honour to the human mind, we are indebted to the monks of the middle ages, who in their seclusion, free from the necessity of providing for their support, employed the time during which they were not engaged in their devotions in the practice of various useful arts. Among the inventions which we owe to them are clocks or time-keepers, which are set in motion by wheels, pendulums, and steel springs. The word *horologium* was in use even among the ancients; and it might almost be inferred, from many expressions, that they possessed instruments similar to our pocket-watches and chamber-clocks. It is however certain, that their time-pieces were sun-dials, hour-glasses, and clepsydræ. The latter, Julius Cæsar brought with him from Great Britain. It was a clepsydra which Cassiodorus, in the 6th century, recommended to his monks, when a cloudy sky prevented them from observing their sun-dials.

The gourmand Trimalchio, described by Petronius, had a clepsydra in his dining-room, and placed a trumpeter near it to announce the hours. Vitruvius mentions an Alexandrian artist who, 140 years before our era, combined spring-wheels with the clepsydra; but the account is too confused and incomplete to afford a correct idea of its construction. In an old chronicle it is related, that Charlemagne received a clock from Haroun al Raschid in 809, to which small

CLOCK WORK.

Fig. 1.

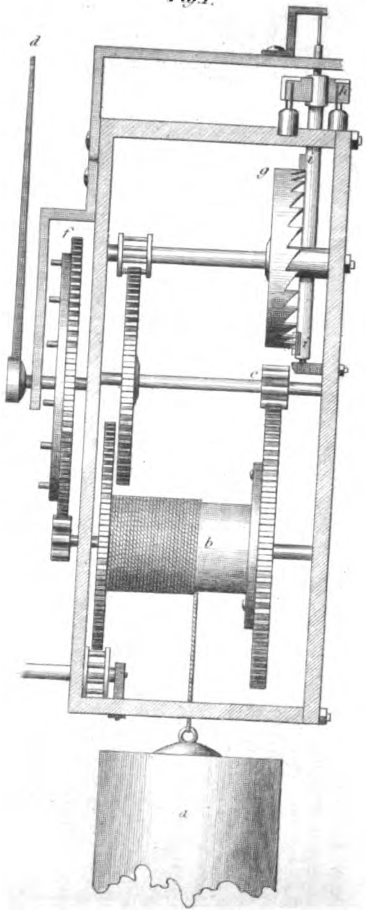


Fig. 3.

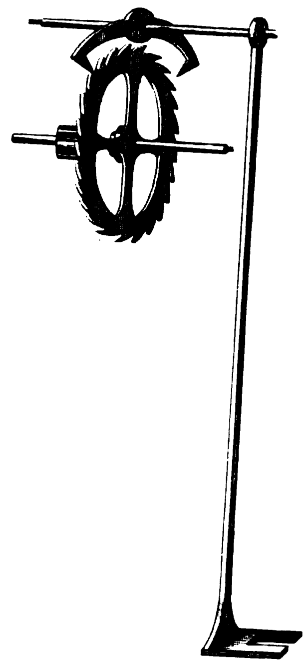


Fig. 2.

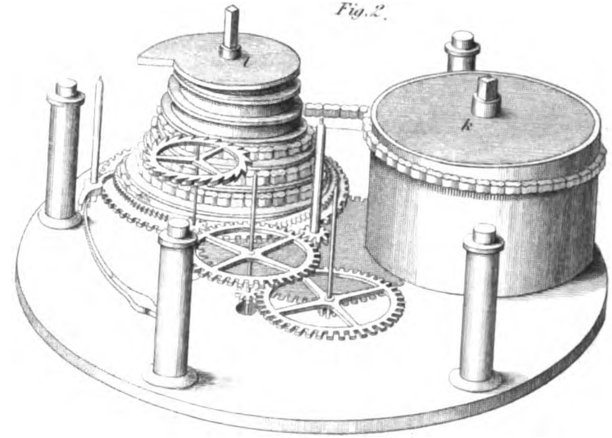
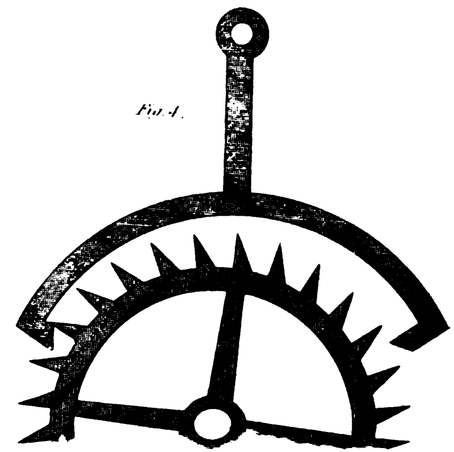


Fig. 4.



London. Published by William Orr Paternoster Row. April 20 1833

bells were attached, and in which figures of horsemen, at the hour of twelve, came forth through little doors, and retired again. There is a more exact description of this work of art in the Franconian annals, attributed to Eginhard, in which it is particularly said to have been a clepsydra, and that, at the end of each hour, little balls of metal fell upon a bell, and produced a sound. It is not probable that the clock which Pacificus, archdeacon of Verona, is said to have invented in the 9th century, could have been equal to our present clocks. The words on his tomb are so indistinct that nothing positive can be inferred from them.

The discovery of clocks has likewise been attributed to the famous Gerbert of Auvergne, who afterwards became pope under the name of *Sylvester II.*, and died in 1003; but Ditmar of Merseburg, a trustworthy witness, only relates that Gerbert placed a *horologium* in Magdeburg for the emperor Otho, after observing through a tube, the star which guides the seamen. This must have been a sun-dial, which Gerbert placed according to the height of the pole.

In the 12th century clocks were made use of in the monasteries, which announced the end of every hour by the sound of a bell, put in motion by means of wheels. From this time forward, the expression "the clock has struck" is often met with. The hand for marking the time is also made mention of. Of William, abbot of Hirschau, his biographer relates, that he invented a *horologium* similar to the celestial hemisphere. Short as this account is, it still appears probable that this abbot was the inventor of clocks, as he employed a person particularly in arranging his work, and keeping it in order. This abbot died at the end of the 11th century.

In the 13th century there is again mention of a clock, given by Sultan Saladin, to the emperor Frederick II. This was evidently put in motion by weights and wheels. It not only marked the hours, but also the course of the sun, of the moon, and the planets in the zodiac. It is hardly probable that the Saracens learned the art of clock-making from the monks of European monasteries: perhaps, on the contrary, they were the real inventors of it, and the invention was made known to the Europeans by means of the crusades. In the 14th century, there are stronger traces of the present system of clock-work. Dante particularly mentions clocks.

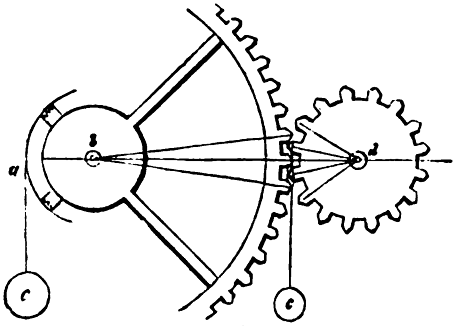
The manufacture of clocks appears to have been introduced into England during the reign of Edward III., as that monarch, in the year 1368, invited three Dutch *Arlogiers* from Delft, for the express purpose of benefiting his subjects by a knowledge of the art. But the oldest clock extant in this country towards the close of the last century, was made in the reign of Henry VIII. It was honoured by a place in the royal palace at Hampton, and was so constructed as to represent the motions of the heavenly bodies. It is a curious fact, that in the writings of two of our best poets, we find the surest data that can be adduced of the early use of clocks and watches in this country. Chaucer, who was born in 1328, says:—

> "Full sickerer was his crowing in his loge,
> As is a *clock*, or any abbey *orloge*."

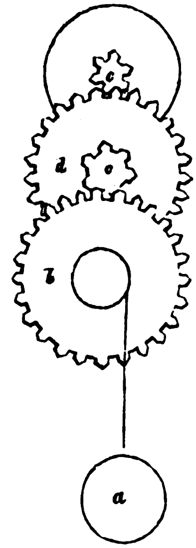
Shakspeare is equally conclusive as to the general use of watches in the time of Elizabeth:—

> "I frown the while, and perchance *wind up my watch*, or play with some rich jewel."—MALVOLIO in "*Twelfth Night*."

As the construction of every modern horological machine must depend mainly on a judicious combination of wheel-work, it may be advisable to examine first the principle of a common wheel and pinion, and then show its application to the movement of a clock.



In the above diagram, the pinion *d* is supported by a separate axis, round which it is made to revolve; and the wheel, *i*, being three times as large as the pinion, the latter will make three revolutions to one of the former, or about one revolution for the portion of a circle shown in the diagram. If we consider the weight *c* as the maintaining power, it will be evident, that for every revolution made by its axis there will be three revolutions of the next wheel in succession.



If we combine a series of wheels and pinions, a still greater increase in speed will result. Thus it will be seen, that there are four revolutions of the pinion *c* for one of the wheel that drives it; and as the wheel *d* is attached to the same axis, the pinion *e* will make sixteen revolutions to one of the prime mover.

A reference to this simple mode of increasing velocity in wheel-work will readily explain why a clock which makes but twelve revolutions at the barrel, is enabled to beat half and quarter seconds, and even go as many days as there are turns at the prime mover.

We pass now to a complete clock, intended to go by the impulse of a weight, and for greater clearness take one constructed on the original balance principle. It is represented in our *plate* CLOCK-WORK, *fig.* 1. The maintaining power or weight, *a*, is seen suspended beneath. It acts on the barrel, *b*, to which is attached a large wheel. The teeth of the barrel-wheel gives motion to the pinion, *c*, which carries the minute hand, *d*. A small nut, at *e*, gives motion to the hour-wheel, *f*. Having thus obtained the division of minutes and hours, the next step is to regulate the motion of the "train" of wheels and pinions: this is effected by the escapement, which consists in the present case of a wheel, *g*, and balance, *h*. The pallets, *i*, *i*, are

intended alternately to take the teeth of the wheel in which they act. This produces the ticking sound, so audible in every species of clock. The balance, *h*, with its weights, continually oscillates backwards and forwards, and by its slow regular motion gives uniformity to the operation of the wheel-work of the clock.

A portable clock is represented at *fig.* 2. Here a bent spring is substituted for the weight. The spring is coiled in the barrel, *k*, and the chain being wound round the fusee, gives motion to the train, as in the former case. The fusee is tapered from the bottom upwards: this is intended to equalize the power of the spring, which when wound quite up, pulls with greater force when its coils are less tightened. In *fig.* 3, the anchor escapement is represented with the wheel detached from the train. Here again the same species of oscillation in the pendulum is employed to regulate the wheel-work. *Fig.* 4, exhibits the dead-beat of Graham, in which the seconds' hand is left in a state of rest between each oscillation of the pendulum. See ESCAPEMENT.

If any substance, sufficiently long for a pendulum, could be found in nature, that has not its dimensions enlarged or diminished by heat or cold, such substance would be the most suitable for a simple attached pendulum; but all attempts to discover such a substance have hitherto been ineffectual. Hence, contrivances have been devised by ingenious men, to counteract the effects of variable temperature in the pendulum, and some of them have succeeded in effecting this desirable purpose. So long ago as the year 1648, the different expansibilities of various metals were known by Wandelim to exist, and in 1715, that ingenious artist, George Graham, made several experiments with the pyrometer, invented by Musschenbrock, to ascertain the relative quantities of expansion in different metals, with a view of availing himself of the difference of the expansions of some two or more metals, when opposed to each other, in the construction of a compensating pendulum; but the difference which he detected, between iron and brass, for instance, was so small, that he relinquished all hope of being able to accomplish his object in this way, and therefore gave up the project. (*Phil. Trans.* London, 1726.) However, it occurred to the same artist, that mercury was affected by changes of heat and cold, sufficiently to answer the purpose of keeping the centre of oscillation of a pendulum always equidistant from the point of suspension, provided the mercury could be made to ascend while the verge of the pendulum descended, or elongated, by any degree of heat; and *vice versâ*. In 1721, the trial was made in a pendulum, which we shall presently describe, and in which the compensation, after some adjustment, was found so complete, that its error in the extremes of temperature was reduced to $\frac{1}{8}$ of the quantity observable in an ordinary simple pendulum. In the mean time, the idea of arranging metallic bars of different expansibilities in such a manner as to constitute a good compensating pendulum, being once suggested by Graham's paper on the subject, roused the ingenuity of different mechanics; and Harrison, a carpenter, of Barton, in Lincolnshire, in the year 1726, succeeded in completing the requisite arrangement. His rods of metal were placed in such parallel situations as to resemble those of a gridiron, from which circumstance the pendulum, so constructed, has been denominated the *gridiron pendulum*. Since Harrison's time, there have been various modifications of the compensating pendulum, both in England and France, the principal of which we shall describe in their order of time, but none of them have been found to excel the prototypes of Graham and Harrison, which are still used, one or other of them, in the principal observatories. If any improvement has been made on the original pendulums, it is in the external appearance, and in the easier modes of adjustment. (See PENDULUM.)

CLOSE-HAULED, in navigation; the general arrangement or trim of a ship's sails, when she endeavours to make progress, in the nearest direction possible, towards that point of the compass from which the wind blows.

CLOSE-QUARTERS; certain strong barriers of wood, stretching across a merchant-ship in several places. They are used as a place of retreat when a ship is boarded by her adversary, and are therefore fitted with several small loopholes, through which to fire the small arms. They are likewise furnished with several small caissons, called *powder-chests*, which are fixed upon the deck, and filled with powder, old nails, &c., and may be fired at any time. Instances are known in which close-quarters have proved highly effective.

CLOTH. See WEAVING and WOOLLEN.

CLOTHING. A very striking fact, exhibited by the bills of mortality, is the very large proportion of persons who die of consumption. It is not our intention to enter into any general remarks upon the nature of that fatal disease. In very many cases, the origin of a consumption is an ordinary cold; and that cold is frequently taken through the want of a proper attention to clothing, particularly in females. We shall, therefore, offer a few general remarks upon this subject, so important to the health of all classes of persons. Nothing is more necessary to a comfortable state of existence, than that the body should be kept in nearly an uniform temperature. The Almighty Wisdom, which made the senses serve as instruments of pleasure for our gratification, and of pain for our protection, has rendered the feelings arising from excess or deficiency of heat so acute, that we instinctively seek shelter from the scorching heat and freezing cold. We bathe our limbs in the cool stream, or clothe our bodies with the warm fleece. We court the breeze, or carefully avoid it. But no efforts to mitigate the injurious effects of heat or cold would avail us, if nature had not furnished us, in common with other animals (in the peculiar functions of the skin and lungs), with a power of preserving the heat of the body uniform under almost every variety of temperature to which the atmosphere is liable. The skin, by increase of the perspiration, carries off the excess of heat; the lungs, by decomposing the atmosphere, supply the loss; so that the internal parts of the body are preserved at a temperature of about 98°, under all circumstances. In addition to the important share which the function of perspiration has in regulating the heat of the body, it serves the farther purpose of an outlet to the constitution, by which it gets rid of matters that are no longer useful in its economy. The excretory function of the skin is of such paramount importance to health, that we ought at all times to direct our attention to the means of securing its being duly performed; for if the matters that ought to be thrown out of the body by the pores of the skin are retained,

they invariably prove injurious. When speaking of the excrementitious matter of the skin, we do not mean the sensible moisture which is poured out in hot weather, or when the body is heated by exercise, but a matter which is too subtile for the senses to take cognizance of, which is continually passing off from every part of the body, and which has been called the *insensible perspiration*. This insensible perspiration is the true excretion of the skin. A suppression of the insensible perspiration is a prevailing symptom in almost all diseases. It is the sole cause of many fevers. Very many chronic diseases have no other cause. In warm weather, and particularly in hot climates, the functions of the skin being prodigiously increased, all the consequences of interrupting them are proportionably dangerous. Besides the function of perspiration, the skin has, in common with every other surface of the body, a process, by means of appropriate vessels, of absorbing, or taking up, and conveying into the blood-vessels, any thing that may be in contact with it. It is also the part on which the organ of feeling or touch is distributed. The skin is supplied with glands, which provide an oily matter, that renders it impervious to water, and thus secures the evaporation of the sensible perspiration. Were this oily matter deficient, the skin would become sodden, as is the case when it has been removed—a fact to be observed in the hands of washerwomen, when it is destroyed by the solvent powers of the soap. The hair serves as so many capillary tubes to conduct the perspired fluid from the skin. The three powers of the skin, perspiration, absorption, and feeling, are so dependent on each other, that it is impossible for one to be deranged without the other two being also disordered. For if a man be exposed to a frosty atmosphere, in a state of inactivity, or without sufficient clothing, till his limbs become stiff and his skin insensible, the vessels that excite the perspiration and the absorbent vessels partake of the torpor that has seized on the nerves of feeling; nor will they regain their lost activity till the sensibility be completely restored. The danger of suddenly attempting to restore sensibility to frozen parts is well known. If the addition of warmth be not very gradual, the vitality of the part will be destroyed. This consideration of the functions of the skin will at once point out the necessity of an especial attention, in a fickle climate, to the subject of clothing. Every one's experience must have shown him how extremely capricious the weather is in this country. Our experience of this great inconstancy in the temperature of the air ought to have instructed us how to secure ourselves from its effects. The chief end proposed by clothing ought to be protection from the cold; and it never can be too deeply impressed on the mind (especially of those who have the care of children), that a degree of cold that amounts to shivering cannot be felt, under any circumstances, without injury to the health, and that the strongest constitution cannot resist the benumbing influence of a sensation of cold constantly present, even though it be so moderate as not to occasion immediate complaint, or to induce the sufferer to seek protection from it. This degree of cold often lays the foundation of the whole host of chronic diseases, foremost amongst which are found scrofula and consumption. Persons engaged in sedentary employments must be almost constantly under the influence of this degree of cold, unless the apartment in which they work is heated to a degree that subjects them, on leaving it, to all the dangers of a sudden transition, as it were, from summer to winter. The inactivity to which such persons are condemned, by weakening the body, renders it incapable of maintaining the degree of warmth necessary to comfort, without additional clothing or fire. Under such circumstances, a sufficient quantity of clothing, of a proper quality, with the apartment moderately warmed and well ventilated, ought to be preferred, for keeping up the requisite degree of warmth, to any means of heating the air of the room so much as to render any increase of clothing unnecessary. To heat the air of an apartment much above the ordinary temperature of the atmosphere, we must shut out the external air; the air also becomes extremely rarefied and dry; which circumstances make it doubly dangerous to pass from it to the cold, raw, external air. But in leaving a moderately well-warmed room, if properly clothed, the change is not felt; and the full advantage of exercise is derived from any opportunity of taking it that may occur.

The only kind of dress that can afford the protection required by the changes of temperature to which high northern climates are liable, is *woollen*. Nor will it be of much avail that woollen be worn, unless *so much* of it be worn, and it be *so* worn, as effectually to keep out the cold. Those who would receive the advantage which the wearing of woollen is capable of affording, must wear it next the skin; for it is in this situation only that its health-preserving power can be felt. The great advantages of woollen cloth are briefly these:—the readiness with which it allows the escape of the matter of perspiration through its texture; its power of preserving the sensation of warmth to the skin under all circumstances; the difficulty there is in making it thoroughly wet; the slowness with which it conducts heat; the softness, lightness, and pliancy of its texture. *Cotton cloth*, though it differs but little from linen, approaches nearer to the nature of woollen, and, on that account, must be esteemed as the next best substance of which clothing may be made. *Silk* is the next in point of excellence, but it is inferior to cotton in every respect. *Linen* possesses the contrary of most of the properties enumerated as excellences in woollen. It retains the matter of perspiration in its texture, and speedily becomes imbued with it; it gives an unpleasant sensation of cold to the skin; it is very readily saturated with moisture, and it conducts heat too rapidly. It is, indeed, the worst of all the substances in use, being the least qualified to answer the purposes of clothing. There are several prevailing errors in the mode of adapting clothes to the figure of the body, particularly amongst females. Clothes should be so made as to allow the body the full exercise of all its motions. The neglect of this precaution is productive of more mischief than is generally believed. The misery and suffering arising from it begin while we are yet in the cradle. When they have escaped from the nurses' hands, boys are left to nature. Girls have, for a while, the same chance as boys, in a freedom from bandages of all kinds; but, as they approach to womanhood, they are again put into trammels in the forms of stays. The bad consequences of the pressure of stays are not immediately obvious, but they are not the less certain on that account. The girl writhes and twists to avoid the pinching which must necessarily attend the commence-

ment of wearing stays tightly laced. The posture in which she finds ease is the one in which she will constantly be, until at last she will not be comfortable in any other, even when she is freed from the pressure that originally obliged her to adopt it. In this way most of the deformities to which young people are subject originate; and, unfortunately, it is not often that they are perceived until they have become considerable, and have existed too long to admit of remedy.

CLOUD. The clouds are aqueous vapours, suspended in the atmosphere. They differ from fogs only by their height and less degree of transparency. The cause of the latter circumstance is the thinness of the atmosphere in its higher regions, where the particles of vapour become condensed. The varieties of clouds are numerous. Some cast a shade which covers the sky, and at times produces a considerable darkness; others resemble a light veil, and permit the rays of the sun and moon to pass through them. Clouds originate like fogs.

The watery evaporations which rise from seas, lakes, ponds, rivers, and, in fact, from the whole surface of the earth, ascend, on account of their elasticity and lightness, in the atmosphere, until the air becomes so cold and thin that they can rise no higher, but are condensed. Philosophers, however, are of very different opinions respecting the way in which the condensation, and the whole formation of the clouds, proceed. De Luc, whose theory is considered the most probable, believes that the water, after its ascent in the form of vapours, and before it takes the shape of clouds, exists in a gaseous state, not affecting the hygrometer, which is the reason why the air in the higher regions is always dry. He explains the clouds to be collections of small vesicles, in the transformation of which from the gaseous state, he believes that caloric operates, in part at least, because, according to his opinion, clouds communicate a degree of heat to the body which they render damp.

According to Huber, clouds are collections of precipitated spherules, and differ by their negative electricity from fogs, the electricity of which is generally positive. If clouds and fogs lose their electricity, rain is produced. These explanations are, however, by no means perfectly satisfactory.

The change of winds contributes essentially to the formation of clouds and fogs. In countries where this change is small and infrequent, as between the tropics, these phenomena of humidity in the atmosphere must be comparatively rare, but, when they happen, the more violent, because a great quantity of vapour has had time to collect. The distance of the clouds from the surface of the earth is very different. Thin and light clouds are higher than the highest mountains; thick and heavy clouds, on the contrary, touch low mountains, steeples, and even trees.

The average height of the clouds is calculated to be two miles and a half. Their size is likewise very different. Some have been found occupying an extent of 20 square miles, and their thickness, in some cases, has been ascertained by travellers who have ascended mountains, to be a thousand feet: others are very thin, and of small dimensions. The natural history of clouds, not as respects their chemical structure, but their forms, their application to meteorology, and a knowledge of the weather, has been well treated by Luke Howard, in his *Essay on Clouds*. He distributes clouds into three essentially different formations. These formations are—1. *cirrus*, consisting of fibres which diverge in all directions; 2. *cumulus*, convex and conical aggregates, which increase from a horizontal basis upwards; 3. *stratus*, layers vastly extended, connected, and horizontal. The clouds are generally assigned to three atmospherical regions, the upper, the middle, and the lower one, to which a fourth, the lowest, may be added. In the upper region, the atmosphere is in such a state, that it can receive and sustain aqueous matter dissolved into its integrant parts. This state of the atmosphere corresponds to the highest state of the barometer. To this region belongs the *cirrus*, which has the least density, but the greatest height, and variety of shape and direction.

It is the first indication of serene and settled weather, and first shows itself in a few fibres, spreading through the atmosphere. These fibres by degrees increase in length, and new fibres attach themselves to the sides. The duration of the *cirrus* is uncertain, from a few minutes to several hours. It lasts longer, if it appears alone, and at a great height; a shorter time, if it forms in the neighbourhood of other clouds. The middle region is the seat of *cumulus*, which is generally the most condensed, and moves with the stream of air nearest to the earth. This region can receive much humidity, but not in perfect solution. The humidity becomes collected, and shows itself in masses rising conically, and resting on the third region. The appearance, increase, and diappearance of the *cumulus*, in fine weather, are often periodical, and correspondent to the degree of heat. Generally, it forms a few hours after sun-rise, attains its highest degree in the hottest hours of the afternoon, and decreases and vanishes at sun-set. Great masses of *cumulus*, during high winds, in the quarter of the heavens towards which the wind blows, indicate approaching calm and rain. If the *cumulus* does not disappear, but rises, a thunderstorm is to be expected during the night. If the upper region with its drying power predominates, the upper parts of the *cumulus* become *cirrus*. But if the lower region predominates (into which the densest vapours are attracted and dissolved into drops), the basis of the *cumulus* sinks, and the cloud becomes *stratus*, which is of moderate density, and its lower surface rests generally upon the earth or the water. This is the proper evening cloud, and appears first towards sun-set. To this belong also those creeping fogs, which in calm evenings ascend from the valleys, and extend themselves in undulating masses. The *stratus* remains quiet, and accumulates layers, till at last it falls as rain. This phenomenon —the dissolution of clouds into rain—is called *nimbus*.

Howard farther makes subdivisions, as, *cirro-cumulus*, *cirro-stratus*, &c. Also the real *stratus*, the horizontal layer of clouds, sometimes rises higher than at other times, which depends on the season, the polar height of the place, or the heights of mountains: the *cumulus* is also sometimes higher and sometimes lower. On the whole, however, the different kinds remain one above another. Thomas Forster has followed Howard in his investigations respecting the clouds, and Goëthe, the German poet, has made an application of this theory in his work entitled *Zur Naturwissenschaft*.

CLOVE. The clove is the unexpanded flower-bud of an East Indian tree somewhat resembling the laurel in its height, and in the shape of its leaves. It appears that, in 1770 and 1772, both clove and nutmeg-trees were transplanted from the Moluccas into the islands of France and Bourbon, and subsequently into some of the colonies of South America, where they have since been cultivated with great success. At a certain season of the year, the clove-tree produces a vast profusion of flowers. When these have attained the length of about half an inch, the four points of the calyx being prominent, and having in the middle of them the leaves of the petals folded over each other, and forming a small head about the size of a pea, they are in a fit state to be gathered. This operation is performed betwixt the months of October and February, partly by the hand, partly by hooks, and partly by beating the trees with bamboos. The cloves are either received on cloths spread beneath the trees, or are suffered to fall on the ground, the herbage having been previously cut and swept for that purpose. They are subsequently dried by exposure for a while to the smoke of wood fires, afterwards to the rays of the sun. When first gathered, they are of a reddish colour, but by drying, they assume a deep brown cast. This spice yields a very fragrant odour, and has a bitterish, pungent, and warm taste. It is sometimes employed as a hot and stimulating medicine, but is more frequently used in culinary preparations. When fresh gathered, cloves will yield, on pressure, a fragrant, thick, and reddish oil; and by distillation, a limpid essential oil. Oil of cloves is used by many persons, though very improperly, for curing the tooth-ache; since, from its pungent quality, it is apt to corrode the gums and injure the adjacent teeth. When the tooth is carious, and will admit of it, a bruised clove is much to be preferred.

The duty on cloves was considerably reduced in 1819; and there has, in consequence, been a decided increase in the consumption of the article; though not nearly so great as it would have been, had it been supplied under a more liberal system. The cloves at present entered for home consumption in Great Britain, amount to about 60,000 lbs. per year, of which a part comes from Cayenne. But the cultivation of the clove in Cayenne depends entirely on the existence of the present system in the Moluccas. The superiority which the latter enjoy over every other place in the production of cloves, is so very great, that were any thing like freedom given to those engaged in their culture, they would very speedily exclude every other from the market.

CLOVE BARK, or CULILAWAN BARK, is furnished by a tree of the Molucca Islands. It is in pieces more or less long, almost flat, thick, fibrous, covered with a white epidermis, of a reddish-yellow inside, of a nutmeg and clove odour, and of an aromatic and sharp taste. It is one of the substitutes for cinnamon, but not much used. We find also in commerce, under the name of *clove-bark*, another bark furnished by the *myrthus caryophillata*. It is in sticks two feet long, formed of several pieces of very thin and hard bark, rolled up one over the other, of a deep brown colour, of a taste similar to that of cloves. It possesses the same properties as the former barks, and may be considered as a substitute for them.

CLUE, of a sail, is the lower corner; and hence *clue-garnets* are a sort of tackles fastened to the clues of the mainsail and foresail, to truss them up to the yard, which is usually termed *clueing-up* the sails. *Clue-lines* are used for the same purpose as clue-garnets, only that the latter are confined to the courses, whilst the clue-lines are common to all the square-sails.

COACH. See CARRIAGE.

COALITION, in chemistry; the reunion or combination of parts which had before been separated.

COALS. See MINE.

COAT OF ARMS; 1. the surcoat worn by a knight; 2. the ensigns armorial of a family; so called, because originally worn on some part of the armour. Their origin is to be referred to the age of chivalry, when they were assumed as emblematic of the adventures, love, hopes, &c., of the knight, and were useful for distinguishing individuals, whom it was difficult to recognize, covered as they were from head to foot with armour. This, perhaps, may even have been the origin of the usage. As every thing else became hereditary in Europe,—estates, dignities, titles, privileges,—so the favourite emblem of the knight became the adopted badge of the family, the figures or characters employed in them began to receive names, and the language and science of heraldry (see HERALDRY) was formed. The right to bear arms thus became a distinctive mark of gentle birth.

COBALT occurs alloyed with arsenic, nickel, and other metals, and mineralized by oxygen and by arsenic acid. It is obtained, after the ore has been roasted and calcined, in the state of an oxide, impure from the presence of other metallic oxides. When this oxide is obtained in a state of purity, and reduced to the metallic state, we are presented with a metal of a white colour, inclining to gray, and if tarnished, to red, with a moderate lustre. Its fracture is compact; it is hard, brittle, and of a specific gravity of 7.8. Like nickel, it is sensibly magnetic, and is susceptible of being rendered permanently so. It undergoes little change in the air, but absorbs oxygen when heated in open vessels. It is attacked with difficulty by sulphuric or muriatic acid, but is readily oxidized by means of nitric acid. There are but two oxides of cobalt known. The protoxide is of an ash gray colour, and is the basis of the salts of cobalt, most of which are of a pink hue. When heated to redness in open vessels, it absorbs oxygen, and is converted into the peroxide. It may be prepared by decomposing the carbonate of cobalt by heat, in a vessel from which the atmospheric air is excluded. It is easily known by its giving a blue tint to borax when melted with it, and is employed in the arts, in the form of smalt, for communicating a similar colour to glass, to earthenware, and to porcelain.

Smalt, or powder blue, is made by melting three parts of fine white sand, or calcined flints, with two of purified pearl-ash and one of cobalt ore, previously calcined, and lading it out of the pots into a vessel of cold water; after which, the dark-blue glass, or zaffre, is ground, washed over, and distributed into different shades of colours, which shades are occasioned by the different qualities of the ore, and the coarser and finer grinding of the powder. Smalt, besides being used to stain glass and pottery, is often substituted in painting, for ultra-marine blue, and is likewise employed to give to paper and linen a bluish tinge.

The muriate of cobalt is celebrated as a *sympathetic ink*. When diluted with water, so as to form a pale

pink solution, and then employed as ink, the letters which are invisible in the cold, become blue if gently heated. It is prepared by dissolving one part of zaffre in two of diluted nitric acid, with the aid of heat, adding to it of muriate of soda one part, and diluting with twenty parts of water. The peroxide of cobalt is of a black colour, and is easily formed in the way already mentioned. It does not unite with acids; and, when digested in muriatic acid, the proto-muriate of cobalt is generated with the disengagement of chlorine. When strongly heated in close vessels, it gives off oxygen, and is converted into the protoxide.

Ores of cobalt: 1. *White cobalt ore*, or *bright white cobalt ore*, consists principally of cobalt and arsenic. Its colour is tin-white, liable to tarnish, with little lustre. It occurs massive and crystallized, in cubes and in octohedrons. It is hard and brittle. Specific gravity, 7.3 to 7.7. Before the blow-pipe it melts, and gives an arsenical smoke and odour. It forms a metallic globule, and gives to borax a blue colour. It occurs chiefly in primitive rocks, and is frequently accompanied with bismuth. It is found most abundantly in Germany, Sweden, and Norway, and also occurs in several other European countries. 2. *Gray cobalt ore* is an alloy of cobalt with arsenic and iron, and is sometimes accompanied with small portions of nickel and bismuth. Its colour is light-gray; liable to tarnish. It occurs massive or disseminated, and is never crystallized. It has been found in the United States, at Chatham, Connecticut, but has not hitherto been worked advantageously. It also occurs in Bohemia, Saxony, and France. 3. *Red cobalt ore* is a hydrated arseniate of cobalt, of a beautiful peach blossom red colour. It occurs massive, disseminated, and in minute crystals. It accompanies other ores of cobalt.

Cockswain, or Coxen; the officer who manages and steers a boat, and has the command of a boat's crew. It is evidently compounded of the words *cock* and *swain*, the former of which was anciently a yawl, or small boat, as appears from several authors, but has now become obsolete.

Codex; with the ancients, that part of the wood of a tree next to the bark. Before the invention of paper, wooden tablets, covered with wax, which were written on with the style, and put together in the shape of a book, were called *codex*. The word was afterwards retained, in times when paper was used for writing, to denote a large book. Thus, important works, particularly old manuscripts of poets, historians, &c., which had been preserved, were called *codices manuscripti*. See Manuscripts.

Coefficients, in algebra; figures put before the letters, to indicate how many times the letter is to be added to itself. Thus $4a$ signifies $a+a+a+a$. If the coefficient is indefinite, it is expressed by a letter, as $b\,a$.

Coffee. The natural history of this valuable plant will be found under that division of our work, but its commercial importance must be noticed here. Coffee is an article of but recent introduction. To the Greeks and Romans it was wholly unknown. Its use appears to have originated in Ethiopia; and it is stated to have been first introduced into Constantinople in 1554, from whence it was gradually adopted in the western parts of Europe. The information we have respecting its introduction into England is, that, in 1652, Daniel Edwards, a Turkey merchant, brought home with him a Greek servant, whose name was *Pasqua*, and who understood the methods of roasting coffee, and making it into a beverage. This man was the first who publicly sold coffee in England, and kept a house for that purpose in George Yard, Lombard Street. At Paris, coffee was nearly unknown, until the arrival of the Turkish ambassador, Solomon Aga, in 1669; about three years after which the first coffee-house is said to have been established in that city. The coffee shrub was originally planted in Jamaica in 1732.

Great attention is paid to the culture of coffee in Arabia. The trees are raised from seed sown in nurseries, and afterwards planted out in moist and shady situations, on sloping grounds, or at the foot of mountains. Care is taken to conduct little rills of water to the roots of the trees, which at certain seasons require to be constantly surrounded with moisture. As soon as the fruit is nearly ripe, the water is turned off, lest the fruit should be rendered too succulent. In places much exposed to the south, the trees are planted in rows, and are shaded from the otherwise too intense heat of the sun, by a branching kind of poplar-tree. When the fruit has attained its maturity, cloths are placed under the trees, and upon these the labourers shake it down. They afterwards spread the berries on mats, and expose them to the sun to dry. The husk is then broken off by large and heavy rollers of wood or iron. When the coffee has been thus cleared of its husk, it is again dried in the sun, and, lastly, winnowed with a large fan, for the purpose of clearing it from the pieces of husks with which it is intermingled. A pound of coffee is generally more than the produce of one tree; but a tree in great vigour will produce three or four pounds.

The best coffee is imported from Mocha, on the Red Sea. This kind, which is denominated *Mocha* and *Turkey coffee*, is of a better quality than any which the European colonists are able to raise, owing, as it is supposed, to the difference of climate and soil in which it grows. It is packed in large bales, each containing a number of smaller bales, and when good, appears fresh, and of a greenish-olive colour. The coffee next in esteem to this is raised in Java and the East Indies; and that of lowest price, in the West Indies and Brazil. When stowed in ships, with rum, pepper, or other articles, it is said that coffee contracts a rank and unpleasant flavour; and this has been assigned as a reason of the inferiority of that which is imported from the European plantations.—The quantity of coffee annually supplied by Arabia is supposed to be upwards of 14,000,000 of pounds. Before the commencement of the French revolution, the island of St. Domingo alone exported more than 70,000,000 of pounds per annum; and, at the present day, such is the fertility of this island, that sufficient coffee is raised to reduce the price greatly in all parts of the civilized world. Almost all the Mohammedans drink coffee at least twice a day, very hot, and without sugar.

The excellence of coffee depends in a great measure on the skill and attention exercised in roasting it. If it be too little roasted, it is devoid of flavour, and if too much, it becomes acrid, and has a disagreeable burnt taste. In Europe, it is usually roasted in a cylindrical tin box, perforated with numerous holes, and fixed upon a spit, which runs lengthwise through the centre, and is turned by a jack, or by the hand. Coffee is used in the form either of an infu-

sion or decoction, of which the former is decidedly preferable, both as regards flavour and strength. Coffee, as very commonly prepared by persons unacquainted with its nature, is a decoction, and is boiled for some time, under a mistaken notion that the strength is not extracted unless it be boiled. But the fact is just the reverse. The fine aromatic oil, which produces the flavour and strength of coffee, is dispelled and lost by boiling, and a mucilage is extracted at the same time, which also tends to make it flat and weak. The best modes are, to pour boiling water through the coffee in a biggin or strainer, which is found to extract nearly all the strength; or to pour boiling water upon it, and set it upon the fire, not to exceed ten minutes. Prepared in either way, it is fine and strong. As a medicine, strong coffee is a powerful stimulant and cordial, and in paroxysms of the asthma is one of the best remedies; but it should be very strong, and made with almost as much coffee as water. In faintness or exhaustion from labour and fatigue, and from sickness, coffee is one of the most cordial and delicious restoratives. There are coffee-machines, in which the water is boiled, and the steam penetrates the coffee, and extracts, to a great degree, the fine aroma. Immediately after, the boiling water is poured over it. Thus the best coffee is made. As we have already said, in Europe, coffee is generally roasted in a cylinder; in Asia, however, open pans or tin plates are used, and, if the time allows, a boy is employed, who picks out every bean when it has reached the right degree of brownness. The same is done by some French people. The second difference in the Asiatic way of preparing coffee is, that they pound the beans, and do not grind them, much preferring the former mode. In Marseilles, we have seen coffee likewise pounded. Whether this is really preferable, we do not venture to decide; but experience has taught us that the Asiatic coffee is, on the whole, much better than the European. The difference is probably owing to the different way of roasting. The Turks and Arabs boil the coffee, it is true, but they boil each cup by itself, and only for a moment, so that the effect is, in fact, much the same as that of infusion, and not like that of decoction. They do not separate the coffee itself from the infusion, but leave the whole in the cup. It improves the beverage very much to roast and grind the coffee just before it is used.

The Turks drink coffee at all times of day, present it to visitors both in the forenoon and afternoon, and the opium-eater lives almost entirely on coffee and opium. Beaujour, in his excellent work on Greece, tells of a *theriacophage* (an opium-eater), who drank more than 60 cups of coffee in a day, and smoked as many pipes. Coffee has been the favourite beverage of many distinguished men. Napoleon and Frederick the Great drank it freely; Voltaire liked it very strong; and Leibnitz drank it also during the whole day, but mixed with more than an equal quantity of milk. The best coffee, in the western part of the world, is made in France, where this beverage is in universal request. In fact, throughout the continent of Europe it is generally drank. In England, however, tea is a more common drink. In England and the United States, coffee, almost always, is badly made. The coffee-houses in France, it is well known, are places which afford much opportunity for interesting observation. In the south of France, they are still more frequented than in the north. The different *Cafés* of the *Palais Royal* in Paris are famous: the *Café des Mille Colonnes* is one of the most splendid. The *Café de la Paix* contains a small theatre. In the *Café des Aveugles*, every evening, blind men and women of the *Hospice des Quinze-Vingts* play and sing. Those coffee-houses in France where smoking is allowed, are called *estimanets*, which is also the name of the beer-houses in Holland. One of the greatest attractions in French coffee-houses is the *limonadière*, a woman who sits in an elevated seat, to attend to the sale of the refreshments. She is generally very pretty, and is dressed with much taste. With genuine French tact, she represses all improper freedoms.

In the East, the coffee-houses, or rather booths, form a very essential part of the social system; all men of leisure assembling there. In these places are also to be found the famous story-tellers, who repeat long tales to attentive hearers, who show their interest by exclamations of "God save him! Allah deprive him of his eyes!" &c., or utter warning cries to alarm the hero when danger awaits him. It often happens that the story is broken off and continued the next day. There is a highly interesting manuscript in the Royal Library at Paris, in Arabic, entitled the *Support of Innocence*. It relates to the lawfulness of using coffee. The author is Aljeziri Alhanbali. Of this De Sacy gives an account and extracts in his *Chrestomathie Arabe*. It appears that a question arose, whether coffee was to be included among the intoxicating beverages which the Koran prohibits; and the manuscript proves that it is not. There are many other interesting matters in these extracts. The sheikh, the writer of the manuscript, proves that the use of coffee was first introduced by a famous sheikh, imaum, mufti and scholar of Arabia Felix, called *Dhabani*, about the year 870 of the Hegira.

In Egypt, the drinking of coffee seems to have been at first regarded almost as a religious ceremony. The devotees, who introduced it there, assembled for the purpose of enjoying it on Monday and Friday evenings, when it was handed round with great solemnity, accompanied with many prayers, and ever and anon with exclamations of "There is no God but God!" There are also mentioned, in the manuscript above cited, two different methods of making coffee, one called *buniyya*, in which the grain and husk are used together, and another called *kishariyya*, in which the husk is used alone. Many sermons against coffee-drinking are extant, written at the time when it was introduced into Europe; as there are also many sermons against smoking. We recollect having read the following passage in an old sermon: "They cannot wait until the smoke of the infernal regions surrounds them, but encompass themselves with smoke of their own accord, and drink a poison which God made black, that it might bear the devil's colour."

COFFIN. Coffins were used by the ancients only to receive the bodies of persons of the highest distinction. Even at the present time, they are not used in the East, either by Mohammedans or Christians. The modern Jews do not use coffins, but only two boards, between which the corpse is tied. But in Egypt, coffins seem to have been used in ancient times universally. They were of stone, wood, or a kind of pasteboard made by gluing cloth together.

Coffins among Christians were probably introduced with the custom of burying. It has been often proposed that they should be made with a hole opposite the place of the mouth of the body, so as to allow breathing, in case of revival. Of course it would be necessary, at the same time, to let the coffin stand for some days in a convenient place, as is the custom in many parts of Germany.

Cohesion is that force which preserves in union particles of a similar kind. Its action is seen in a solid mass of matter, the parts of which cohere with a certain force which resists any mechanical action that would tend to separate them. In different bodies, it is exerted with different degrees of strength, and is measured by the force necessary to pull them asunder. According to Sickingen, the relative cohesive strength of the metals is as follows:

Gold	150,955
Silver	190,771
Platina	262,361
Copper	304,696
Soft iron	362,927
Hard iron	559,880

Cohesion in liquids is very much weaker, the parts being disjoined with much more facility; and, in substances existing in the aerial form, it is entirely overcome, the particles, instead of attracting, repeling each other.

Cohesion in bodies is weakened or overcome by two general causes—by the repulsion communicated by caloric, or by the attraction which may be exerted by the particles of one body on those of another.—Caloric communicated to a solid body separates its particles to greater distances, as is evident from the enlargement of volume which it produces. By thus increasing the distances, the force with which the attraction of aggregation or cohesion is exerted is diminished; if the heat be carried to a sufficient extent, the cohesion is so far weakened, that the body passes into the liquid form; and, if carried still farther, the attractive force is entirely overcome, repulsion is established between the particles, and the body passes into the aeriform state.

Coining. This subject is intimately connected with the value of *money* as a branch of commerce: but to render our view of the matter clear and methodical, it may be advisable to separate the mechanical manufacture of coin from its use as a circulating medium. The latter portion of the subject will be found under Money. Mr. B. Cook has taken some pains to trace the early history of money, and he states in a paper inserted in the *Journal of Science*, that the Scythians were the first inventors of coined money. The most ancient money struck in Greece is easily known, from the method used in making it, because it has *no reverse;* it appears, they found a difficulty in fixing the coin firmly in the die to receive the stroke of the hammer; to effect this, they left upon the reverse several elevations, which entered into the plate or matrix, to prevent it from slipping. These points or elevations were numerous in the first monies, but in time, this rude method was exchanged for a surface a little convex, which served to hold the coin, while the obverse was struck upon it. Upon coins now existing of Syracuse and India, this method is evident.

It appears that the first Greek monies which had any inscription on the reverse, were cut in after the coin had been struck. The obverse was struck first, and then the coin was put in another die, and struck again, with a reverse; and this method appears to have been generally adopted by the people of Japan, as well as Greece.

Some of the first medals of Greece had, for a reverse, the head of Apollo, with his lyre; thus upon the medals of Crete, the head of Apollo appears, who was one of the deities worshipped there; and because Minos pretended to be descended from Jupiter, he was an object of the highest adoration. Idomeneus, who fought at the Trojan war, also attributed his birth to Apollo, the god of day; the eagle, also, is found on the Cretan coins.

A great quantity of coins and medals of Athens, and other cities, were square; and indeed, all over Asia and Africa, there circulated not only square money, but octagon money. There also existed in France, in the time of the Emperor Honorius, a square money, made of red copper, upon the reverse of which was struck the figure of the goddess *Moneta*, with the legend *Exacium Solidi*, weighing about four penny-weights; the form of this money was like the money of Athens.

Upon the money of Thrace we find the head of Apollo, and on the reverse, a griffin; also on some of their medals is represented Jupiter, with an eagle on his hand, and a sceptre; on the medals of Macedonia is represented a horse; upon the medals of Corinth, the face of Minerva is represented, and on the reverse, the *Pegasus*.

The medals of the island of Cos, the birth-place of Appelles and Hippocrates, had the head of Hercules, and on the reverse, the figure of a crab.

There was struck a money of a parallelogram shape, at Pæstum, with a Latin inscription, which proves the time it was made; this ancient Greek city was forced to receive a Roman colony, 465 years after the foundation of Rome, and 289 years before Christ; these Latin medals could not have been struck before this period, which was more than 40 years after the death of Alexander. The square money is never found among the Roman coins, as the severe spirit that called into existence science and arts at Rome, appears under a different shape to that sublime spirit that gave existence to the everlasting inventions of Greece. If, then, any coins of this shape are found with a Roman legend on them, it is certain they were struck in Greece.

If we seek for authority from Plutarch, he says, that Theseus struck the figure of the bull upon the Athenian money, either in honour of his having conquered the bull of Marathon, or, what is more probable, as an emblem of the deity worshipped at Athens; at all events, money with this figure upon it, was used in Athens before the war of Troy; for his successor, *Ménesthée*, commanded the Athenians at that celebrated siege. It was on account of the figure of a bull being struck upon this money, that it was called by the name of this animal.

Upon the medals of *Pandosia* (a city of Greece, now destroyed) is the same impression, which was famous in history, for the defeat and death of Alexander, king of Epirus, who was killed near to its walls, in the same year that the foundation of Alexandria in Egypt was laid. Now, two of the sons of Theseus fought under Agamemnon at the siege of Troy, and leading there the Athenian youth—a city of the greatest influence among the other states—it

is very likely that the money of their father and others, as well as of other states, which had the same impression, was the money then used by the Greeks, both in gold, silver, and brass; for we find that Homer, in speaking of the arms of *Glaucus*, exchanged for those of Diomede, says, that the golden arms of Glaucus were valued at a hundred oxen or bulls; and those of brass, of Diomede, were only valued at nine oxen. *Iliad*, l. 6, v. 235.

It is very certain it could not be animals that were exchanged as money, but money called by this name; so that in 2000 years hence, when the money of this country is described as *sovereigns*, it will not be supposed that sovereigns, mighty men, kings, were in such plenty, as to be used in making exchanges for things to supply our wants, necessities, or luxuries.

It was about the time of Servius Tullius, that the coins of Rome began to take a different figure; the first coins were cast in moulds, with the figures on them very much raised, and rude, and after being made, were adjusted to a certain weight, to correct the errors of casting. These first monies were chiefly of lead; but Numa began to make money of copper, and introduced other designs on it, as all the former coins had only the double head of Janus on one side, with a ship or prow of a vessel on the other.

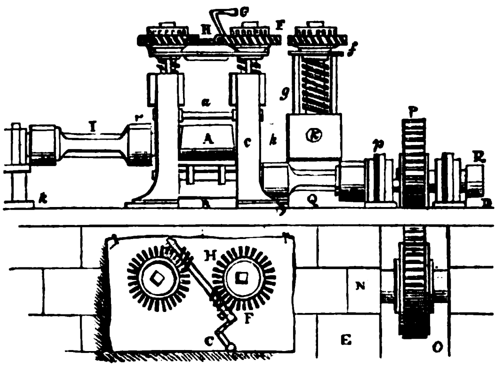
On some medals of *Commodus*, the Supreme Deity is represented under the form of a bull, as indicative of his supreme power. On the reverse of some of the medals of Marcus Aurelius are seen the bull and serpent. On the medals of Persia, and in the works of Zoroaster, this worship was practised. He represents God under the figure of the serpent, and describes him as "the Master of all things—exempt from death—eternal in his duration—without beginning, and without parts."

On the medals of Tartary we find the figure of the serpent; on the reverse of a medal of Tyre we find the serpent encircling an egg; and we find the same figure on the medals of Japan, who, in their cosmogony, say it was the warm breath of the serpent that called into life the first man. In the cosmogony of Phœnicia, *Sanchoniathon* describes "*the first beings as being awakened by a voice of thunder, which spoke to them, calling them male and female on the earth and in the sea; and they began to move.*"

Passing, however, from the ancient coinage to that which relates to our own times, we find a most extraordinary change in the value and execution both of coins and medals effected by the improvements which have taken place in machinery. Copper money manufactured at Birmingham is now equal in point of execution to that of much of the finest gold coinage, without incurring one thousandth part of the expense. Under the article MEDAL we propose giving a history of those splendid specimens of art produced under the patronage of Napoleon, as well as the exquisite medals of Wyon in our own country; and we now proceed to describe the apparatus by which the form is communicated both to coins and medals.

The first process is that of *flatting*, or laminating in the rolling-mill. When silver is to be coined, the bars, before they are passed between the rollers, are heated to redness, which tends to soften them. This is effected in a reverberatory furnace.

When bars of gold are subjected to the same process, they are rolled in a cold state, and a bar of an inch thick can be reduced to that of a half sovereign, without being annealed, and could be made much thinner if necessary, and yet not show the least symptom of cracking.



The above engraving is an elevation of one pair of rollers, and a part of the wheel-work for giving motion to them. A is the upper and B the lower roller; C, the standards, or cast-iron frame which supports them. Each of the standards has an opening in it to receive the bearing brasses for the pivots of the rollers. The upper roller is suspended in brasses, which are regulated by the large screws, F, which admit of placing the rollers at a greater or less distance asunder. In the end view, *h* represents one of the brasses, and *k*, the hole to receive the pivot of the roller. On the upper part of the screw a collar, *f*, is fitted; and from this, two bolts, *g*, *g*, descend and are fastened to the brasses, *h*, with nuts beneath. By these the roller is suspended; but, by turning the screw round, the brasses rise or fall; the brasses are fitted very accurately into the grooves or openings in the standards, C, C.

For the convenience of turning both screws round together, each has a toothed wheel, F, fixed on the upper end of it. These are turned by worms, H, H, fixed on a common axis, which has a handle, G, in front: by turning this handle, the upper roller is either raised or lowered, as is required, but will always be parallel to the lower one. The horizontal view of this apparatus is shown beneath. The two standards are firmly bolted down to the ground sill, which is of cast iron, and bedded in the masonry, E, beneath. The standards are farther united by bolts. At the upper part is a cross-bar fixed between the standards, to support a small table or platform, on which the metal is placed when it is to be presented to the rollers.

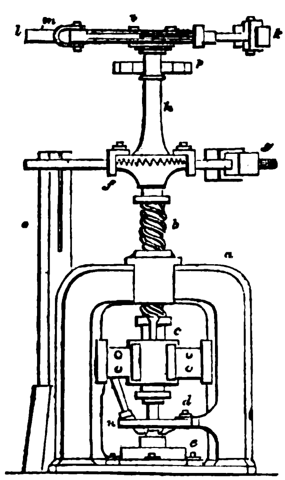
The rollers are put in motion by a steam-engine. The crank of the engine has a toothed wheel upon it which turns a pinion. Upon the axis of this is a very heavy fly-wheel, which turns with great velocity. On the end of the same axis is a pinion, which turns a large wheel, and this gives motion to the shaft, N, which extends beneath the rollers, and is continued a sufficient distance in the same direction to turn two pairs of rollers, one of which only is represented in the engraving at I, and supported by the standard, *k*. A wheel is fixed on this shaft to turn the upper roller, and its axis is connected with a short shaft, with the square on the end of the

roller. The wheel P, is fixed on the shaft, R, to turn the lower rollers by means of the wheel O.

There is also a gauge to ascertain the thickness of the plates, which are reduced by the operation of the rollers; it consists of two steel rulers, fixed fast together at one end, and the other end is a certain distance asunder, forming an opening between them, which gradually diminishes to nothing: the sides of the rulers are divided. In using this gauge to determine the thickness of a piece of plate, the edge of the plate is applied to the opening between the rulers, and the divisions of the rulers show the distance it will go into the opening before it fits tight; and the thickness is ascertained by the number of the divisions.

The plates of metal which have thus been rolled to the required thickness, are then cut into the required width, dependent on the coin to be struck from them. The metal is afterwards still farther adjusted for thickness, either by a second rolling, or by a straw bench, which is similar in its effects. The slips of metal produced from this machine are considerably more uniform in thickness than when finished at the first pair of rollers; consequently the individual pieces are made more nearly to the standard weight, which was the object in view in this invention. When the pieces cut from slips of metal prepared by the drawing-machine, are counted and weighed, which is telling the number of pieces in a pound troy, sovereigns, or half-sovereigns, the variations from standard, either way, seldom exceed three grains troy. It is reckoned good work from the adjusting rollers when the variations are under six troy grains.

The plates of metal prepared by the adjusting rollers, or the drawing-machine, are cut out into circular pieces, of nearly the size of the intended coin. This



is done by the cutting-press, of which *a* is a cast-iron frame, which is fixed on a stone basement; *b* is the screw, which is fitted through the top of the frame, and actuates a slider, *c*. At the lower end of the slider a steel punch, *d*, is fixed. Its diameter is exactly equal to that of the pieces which are to be cut out. Beneath is the steel die, which has a hole in it of proper size to fit the steel punch; on the other side is a box with screws for adjusting the die, so that the hole in it will be exactly beneath the punch. The slide, *c*, is fitted into a socket, which guides it so that it will descend correctly into the hole in the die; *n* is a piece of iron which is fixed a small distance above the die; it has a hole through to admit the punch. Its use is to hold down the piece of metal when the punch rises, otherwise the piece would stick to the punch.

On the upper end of the screw a piece, *f*, is fixed, and an arm projects from it with a weight, *g*, at the end; and it is this weight which gives the necessary momentum to punch out the piece; *h* is a spindle fixed upon the piece, *f*, in the line of the screw; it is supported in a collar, *p*, at the upper end, and above the collar, a lever, *i*, *m*, *k*, is fixed, and at one extremity of this lever a roller, *k*, is placed, and this is acted upon by projecting teeth, which are fixed in the rim of a large horizontal wheel, which is turned round by the power of the mill, and thus produces the requisite motion in the whole apparatus.

The blanks, after being cut to the required size, are examined and then filed to the exact weight. They are then passed through the fire and milled on the edge; the latter process being effected by two saw-like bars of steel, between which the coin is rolled.

The last process to be noticed is that of stamping, which is performed with a screw-press, and the momentum of two heavy weights acting on a punch is employed to form the impression.

The punch or die is formed of steel, and cut with the required figure on the surface, partly by graving tools, and partly by small steel chisels. It is afterwards hardened, and if this part of the process be well performed, will strike many thousand pieces of money.

Coke. Since writing our article Carbon, we have been favoured by the perusal of a memoir on the calcination of coke, which has been furnished for the French government by Messrs. Perdonnet and Leon Coste.

Coke is obtained in England by two distinct processes; in the open air, and by means of ovens constructed for the purpose. The former is the method usually adopted, the latter being applied almost exclusively to the small coal or slack. In the vicinity of Dudley, in Staffordshire, all the coke is made in open air; the process consists in forming a small conical chimney, with bricks placed in such manner as to leave spaces between them; these openings are larger in the lower than in the upper courses; the usual height is about four feet six inches, surmounted by a cylinder of one foot. The coal is then disposed around the chimney, the largest lumps being placed first to form the base of a cone, after which more is thrown on the heap, until the top is above the level of the brickwork; the whole surface is then covered with slack, with the exception of the lowest part of the heap, to about one foot high; the fire is then lighted in the chimney; at a certain period of the operation the remaining part is also covered with slack, and when the carbonization is judged to be complete, the fire is extinguished, by throwing on a sufficient quantity of water and dispersing the materials of the heap.

The dimensions of the coke heaps vary considerably; they are most commonly fourteen or sixteen feet in diameter, and contain about twelve ton of coals. From the time of lighting the pile the operation is completed in seven days, three for the calcina-

tion, and four for the extinction and subsequent cooling of the mass.

It would appear that a method so simple as this would be invariable in the results; nevertheless the contrary is the fact, much depending on the attention and judgment of the burner or superintendant. A ton of coal usually yields twelve cwt. of coke, or sixty per cent., sometimes ten cwt., or fifty per cent. from the same materials. In South Wales both methods are practised, but the coke is not calcined with so much attention as in Staffordshire: the process differs in the heap being made in the form of a long bank four to six feet in breadth, and about three feet high; the large coals in the middle, and the fire being lighted either at one end or at several parts of the heap. At Pontypool and Abergavenny the coke is calcined in the open air; the coal in some parts of this district bears a resemblance to charcoal; in converting it into coke, great care is taken to preserve this entire; the operation is completed in five days. In the neighbourhood of Merthyr Tydvil the process is conducted in the open air, and although very little care seems to be given to its progress, yet a considerable quantity of coke is produced, the coal being generally dry, and giving but little smoke. At Plymouth works six tons of coal yield five tons of coke; at Dowlay 720lbs. of coal yield from 450 to 500lbs. of coke; at Pen-y-Darran, the operation lasts only three days, the increase in bulk being also very considerable, three tons of coal producing twelve barrows of coke, each containing seventeen cubic feet, or above one-fourth part more than previous to calcination.

At Neath Abbey the carbonization is more rapid than in any other place, it being finished in nine hours, producing rather less than sixty per cent. of coke. In Scotland, calcination in the open air is generally adopted; formerly the heaps were burned without much attention being paid to their progress; but the Staffordshire mode has been used latterly with great advantage, the heaps consisting of eighteen tons of coal, well covered with slack, kept burning three or four days, and four or five days more being allowed for the cooling of the mass; the loss in weight is about fifty per cent.; the old method occupied only five days, but the loss amounted to from sixty to sixty-six per cent. The coke is of very unequal quality, some parts being very heavy, and others light and porous. In Yorkshire the coal is arranged in long banks, six feet wide by two and a half high, with square vertical chimneys, eight or nine inches in diameter, formed with large coals, at about the distance of six feet from each other throughout the length; the loss is about fifty per cent. in weight.

Calcination in ovens is considered to produce a heavier coke than the open calcination; the process varies but little, being in all cases performed in ovens of a circular or oval form, with a low arch surmounted with a small chimney; the furnace has two doors or openings opposite to each other, sliding in a groove and raised by a lever; they are usually of cast iron; the dimension of the furnace about twelve feet by six; height of the arch in the centre five feet, at the door twenty-one inches; the chimney is eighteen inches externally, and about nine inches in diameter. At Neath Abbey the furnaces are smaller; the chimney is 18 inches externally, and only one door; but in this case a hole is made in the opposite side to facilitate the clearing out of the coke. From the small coal carbonized in this manner the produce is about sixty per cent., while the same quantity of coal in the open air yields but fifty per cent., the coke from the furnace being so much more dense. At Swansea, by the same process, the produce is about fifty-four per cent.

In the vicinity of Glasgow a circular oven with one door is in use; the diameter is nine feet, height of the arch six feet. The coke is drawn out every twenty-four hours; the ordinary charge, one ton and a half of coal, rising about two and a half feet in the oven; the loss is from fifty to sixty per cent. On Saturdays the charge is increased to two tons, and is not withdrawn until the Monday. At the Lymington works, near Newcastle-upon-Tyne, all the coke is made in ovens; the usual charge is one chaldron of about two and a half tons; the operation lasts forty-eight hours, and the average loss thirty-nine per cent. The coke is screened to the diameter of about one inch for smelting in the high furnace, the smaller portion being employed in roasting the ores. At Bradford, in Yorkshire, the method is similar to Newcastle, but the furnaces are smaller, the charge being only about one ton; the loss is about 40 per cent. It is difficult to decide to which process a preference ought to be given; the loss is less in the ovens, but they require more space, more attendants, and more expense, while the open carbonization is considered to yield coke better adapted for smelting in the high furnace.

Colchicum, or Meadow Saffron, has of late years become quite celebrated as a remedy for that bane of a luxurious life, the gout. It is a very powerful remedy, and should never be used without the attendance and advice of a well-educated medical practitioner, as its effects might otherwise be highly injurious. It is now believed to be identical with the base of the *eau médicinale*, which has been, for so long a period, a celebrated empirical remedy for the gout. It is used in various forms, either the powdered root, or vinegar or wine in which it has been steeped, or, which is considered the best, wine in which the fresh seeds have been steeped. It is also used with benefit in many cases of rheumatic affections, which often so much resemble the gout.

Colcothar is an impure brownish-red oxide of iron, which remains after the distillation of the acid from the sulphate of iron. It forms a durable colour, but is most used by artists in polishing glass and metals.

Cold. All temperature is comparative, and as such but little can be understood of the philosophical character of this subject till we come to the article Thermometer. But the effects of cold are so peculiar, and the phenomena of a diminished temperature in the warmer seasons of the year so important to domestic comfort, that it is advisable to devote a page to the subject.

The Moors introduced into Spain a sort of unglazed earthen jugs, named bucaros, or alcarrazas, which, being filled water, present to the atmosphere a surface constantly humid, and furnish by evaporation, during the dry and hot weather, a refreshing beverage. The same practice has been adopted by degrees in various parts of the south of Europe. In India, the apartments are kept comparatively cool by dashing water against the matting suspended round the walls.

The natives of India, likewise, are enabled, by directing a skilful process of evaporation, to secure for themselves a supply of ice during their short

winter. In the upper country, not far, indeed, from Calcutta, a large open plain being selected, three or four excavations are made in it about thirty feet square and two feet deep, and the bottom covered to the thickness of nearly a foot with sugar-canes, or dried stalks of Indian corn. On this bed are placed rows of small unglazed earthen pans, about an inch and a quarter deep, and extremely porous. In the dusk of the evening, during the months of December, January, and February, these are filled with soft water, previously boiled and suffered to cool, and when the weather is very fine and clear, a great part of the water becomes frozen during the night. The pans are regularly visited at sun-rise, and their contents thrown into baskets which retain the ice. These are now carried to a conservatory made by sinking a pit fourteen or fifteen feet deep, lined with straw, under a layer of coarse blanketing. The small sheets of ice are thrown down into the cavity, and rammed into a solid mass. The mouth of the pit is then closed up with straw and blankets, and sheltered by a thatched roof, so that the ice is readily preserved.

From the above observations it will be seen that a reduction of temperature always accompanies a rapid evaporation. But there are chemical processes for accomplishing the same object, which must be noticed. It consists in the use of a frigorific mixture, the ingredients for which will be best understood by reference to the two following tables:—

TABLE I.

Consisting of Frigorific Mixtures, having the power of generating or creating Cold, without the aid of Ice, sufficient for all useful and philosophical purposes, in any part of the world, at any season.

FRIGORIFIC MIXTURES WITHOUT ICE.

Mixtures.	Thermometer sinks.	Degree of cold produced.
Muriate of ammonia 5 parts. Nitrate of potash . . 5 .. Water. . . . . . 16 ..	From + 50° to + 10°.	40
Muriate of ammonia 5 parts. Nitrate of potash . . 5 .. Sulphate of soda . . 8 .. Water. . . . . . 16 ..	From + 50° to + 4°.	46
Nitrate of ammonia . 1 part. Water . . . . . 1 ..	From + 50° to + 4°.	46
Nitrate of ammonia . 1 part. Carbonate of soda . 1 .. Water . . . . . 1 ..	From + 50° to — 7°.	57
Sulphate of soda . . 3 parts. Diluted nitric acid . 2 ..	From + 50° to — 3°.	53
Sulphate of soda . . 6 parts. Muriate of ammonia 4 .. Nitrate of potash . . 2 .. Diluted nitric acid . 4 ..	From + 50° to — 10°.	60
Sulphate of soda . . 6 parts. Nitrate of ammonia . 5 .. Diluted nitric acid . 4 ..	From + 50° to — 14°.	64
Phosphate of soda . 9 parts. Diluted nitric acid . 4 ..	From + 50° to — 12°.	62
Phosphate of soda . 9 parts. Nitrate of ammonia 6 .. Diluted nitric acid . 4 ..	From + 50° to — 21°.	71
Sulphate of soda . . 8 parts. Muriatic acid . . . 5 ..	From + 50° to 0°.	50
Sulphate of soda . . 5 parts. Diluted sulphuric acid 4 ..	From + 50° to + 3°.	47

TABLE II.

Consisting of Frigorific Mixtures, composed of Ice with Chemical Salts and Acids.

FRIGORIFIC MIXTURES WITH ICE.

Mixtures.	Thermometer sinks.		Degree of cold produced.
Snow, or pounded ice 2 parts. Muriate of soda . . 1 ..	From any temperature	to — 5°.	—
Snow, or pounded ice 5 parts. Muriate of soda . . 2 .. Muriate of ammonia 1 ..		to — 12°.	—
Snow, or pounded ice 24 parts. Muriate of soda . . 10 .. Muriate of ammonia 5 .. Nitrate of potash . . 5 ..		to — 18°.	—
Snow, or pounded ice 12 parts. Muriate of soda . . 5 .. Nitrate of ammonia . 5 ..		to — 25°.	—
Snow . . . . . . 3 parts. Diluted sulphuric acid 2 ..	From + 32° to — 23°.		55
Snow . . . . . . 8 parts. Muriatic acid . . . 5 ..	From + 32° to — 27°.		59
Snow . . . . . . 7 parts. Diluted nitric acid . 4 ..	From + 32° to — 30°.		62
Snow . . . . . . 4 parts. Muriate of lime . . 5 ..	From + 32° to — 40°.		72
Snow . . . . . . 2 parts. Chryst. muriate of lime 3 ..	From + 32° to — 50°.		82
Snow . . . . . . 3 parts. Potash . . . . . . 4 ..	From + 32° to — 51°.		83

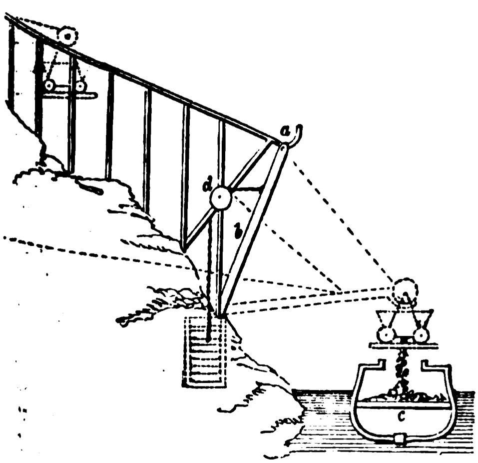
COLIC. The appellation of *colic* is commonly given to all pains in the abdomen, almost indiscriminately; but, from the different causes and circumstances of this disorder, it is differently denominated. When the pain is accompanied with a vomiting of bile, or with obstinate costiveness, it is called a *bilious colic*; if *flatus* causes the pain, that is, if attended with temporary distention, relieved by the discharge of wind, it takes the name of *flatulent* or *windy colic*, when accompanied with heat and inflammation, it takes the name of *inflammatory colic*, or *enteritis*. When the disease arises to a violent height, and is attended with obstinate costiveness, and an evacuation of fæces by the mouth, it is called *passio iliaca*, or *iliac passion*.

Dr. Cullen enumerates seven species of colic. One of the most important is the *colica pictonum*. This is called, from the places where it is endemial, the *Poictou*, the *Surinam*, the *Devonshire colic*; from its victims, the *plumbers'* and the *painters' colic*; from its symptoms, the *dry stomach-ache*, the *nervous* and *spasmodic colic*. It has been attributed to the poison of lead, and this is undoubtedly the cause, when it occurs to glaziers, painters, and those employed in lead works; but, though this is one, it is by no means the only cause. In Devonshire, it certainly more often arises from the early cider, made of harsh, unripe fruit, and in the West Indies from new rum. The characteristics of this disease are, obstinate costiveness, with a vomiting of an acrid or quorraceous bile, pains about the region of the navel, shooting from thence to each side with excessive violence, strong convulsive spasms in the intestines, and a tendency to a paralysis of the extremities.

It is occasioned by long-continued costiveness; by

an accumulation of acrid bile; by cold applied either to the extremities or to the belly itself; by a free use of unripe fruits, and by great irregularity in the mode of living. From its occurring frequently in Devonshire and other cider countries, it has been supposed to arise from an impregnation of lead received into the stomach; but this seems to be a mistake, as it is a very prevalent disease in the West Indies likewise, where no cider is made, and where there is only a very small quantity of lead in the mills employed to extract the juice from the sugar-canes. One or other of the causes just enumerated may justly be said always to give rise to this species of colic. The dry stomach-ache is always attended with some degree of danger, which is in proportion to the violence of the symptoms and the duration of the disease. Even when it does not prove fatal, it is too apt to terminate in palsy, and to leave behind it contractions of the hands and feet, with an inability in their muscles to perform their office; and in this miserable state of existence the patient lingers out many wretched years.

Collier; a vessel much employed for the conveyance of coal from the mining districts, to the London and other great markets. We particularly notice the collier to describe a very improved mode of loading that species of vessel exhibited in the diagram beneath.



On the top of the rail, *a*, which forms part of the staith, the laden carriage is seen descending from the higher level, and when it attains the point *a*, the whole frame, *b*, with the carriage, is lowered down by the chain passing over the pulley at *d*, into the centre of the deck of the vessel, and the coals are received in the hold, at *c*.

Colonel; the commander of a regiment, whether of horse, foot, or artillery. There were times when, in some armies of the European continent, regiments were commanded by generals; but this is no longer the case.

Colonnade; a series or row of columns. Colonnades are of various forms and dimensions, and assume different names according to their application and uses. When in front of a building, or in the interior of a quadrangle, they are called *porticoes;* when surrounding a building of any shape, *peristyles;* when double or more, as in some of the ancient temples and the circular peristyle in front of St. Peter's at Rome, they are *polystyle*. Of this splendid work we give an engraving.

No people have made more use of colonnades, or with greater effect, than the ancient Egyptians; many of their temples being literally thick set, both in the interior and exterior, with colonnades of every description. The Greeks were more simple in their arrangement, and their colonnades were mostly distributed into porticoes and peristyles, both monostyle and polystyle. Their most magnificent example is, perhaps, the temple of Jupiter Olympius, at Athens. Balbec and Palmyra present also various examples of splendid colonnades. Of modern works, the magnificent colonnade of the Piazzo di San Pietro, at Rome, the work of Bernini, is at once the grandest and most beautiful. It consists of two hundred and eighty columns, and forty-eight pilasters, of forty feet high, raised on three lofty steps. It is surmounted by a balustrade, on which are eighty-eight colossal statues of saints, fifteen feet in height. The screen of columns which formerly stood in the front of Carlton Palace, might be cited as an example of one of the most tasteful arrangements of the kind in our own metropolis.

Colour. Colour is a property of light, the knowledge of which can be gained from no description, but is acquired by means of the organ of sight. Colouring substances, or paints, often improperly termed *colours*, are made use of to impart a colour to other substances, either by application or admixture. White and black are counted among colours in the latter sense, but not at all, or seldom in the former, in which sense a white body is very properly called *colourless*. Black is merely the absence of all light.

Colours, both alone and united, have different properties, and produce different effects upon the organs of sense, by means of their harmony or contrast, which are particularly important to painters, and are properties arising from the nervous sensibility. Thus, scarlet is a burning colour, injurious to the eyes; and it is probably on this account that beasts are so violently excited by it. Yellow is the brightest, red the warmest, deep brown and violet the softest among colours. The passing of one colour into another, by mixture, has been displayed in tables, pyramids, &c., for the use of the painter, the colourer, the mineralogist, &c.; but it requires constant familiarity with colours, to make upon the mind impressions sufficiently deep to enable us to distinguish these fine shades of colour with correctness.

Colours, Doctrine of. The doctrine of colours in a general sense, is the science of the origin, the mix-

ture and effects of colour, as a property of light. How, for instance, is it, that light at one time is coloured, at another white? and by what laws are the appearances of colours governed? The glass prism was the first contrivance that gave a satisfactory solution of these questions. If a ray of light is allowed to pass into a dark room through a small opening in a shutter, and is made also to pass through a smooth three-sided glass prism, we find, first, that the ray of light, at its entrance into, and at its passage out of, the glass, is turned from its direct course; it is said to be refracted into a different direction; secondly, that the ray of light, which falling directly upon a piece of paper before the prism, produces a round white spot, produces, when the paper is held behind the prism, a coloured figure, about five times as long as it is wide, and exhibiting the colours of the rainbow, arranged in the same order as they are seen in that phenomenon. This figure or appearance is called the *prismatic spectrum*. The length of it is found to be in a direction perpendicular to the axis of the prism. It is red at the end which is nearest to the refracting angle of the prism, and violet at the end most remote from it, while orange, yellow, green, blue, and indigo follow each other in the intervening space.

Newton concluded from this, and a great variety of similar experiments, that these coloured rays are the simple rays of light, and that white light is composed of the union of them all, according to the relations which they exhibit in the prismatic spectrum. Every white ray of light, therefore, contains all the coloured rays united; but they are not recognized by us, since they produce upon the retina, where they are thus united, the impression we term *white*.

These coloured rays are reflected from all bodies according to similar laws, so that reflected white light is still white; but they are refrangible in different degrees; this property being least in the red rays, moderate in the green, and in the greatest degree in the violet; and they are, on this account separated from each other whenever they are refracted; since from their different refrangibility, although they are parallel, when they fall upon the refracting substance, they take different lines of direction in passing through it. They follow each other, in this respect, in the following order: first violet, then indigo, blue, green, yellow, orange, and red. When these same coloured rays are rendered parallel again, and so fall upon the eye, they appear white, as at first.

Most bodies possess the property of fixing or absorbing some of these coloured rays, which fall upon them, and thus only reflect or transmit rays of a particular colour; and upon this property, according to Newton, the colours of all bodies depend. Blue silk, for example, absorbs six coloured rays, and reflects only the blue; and a solution of cochineal transmits only the red, and absorbs all the other rays. All this is confirmed by the experiments with coloured disks revolving rapidly upon a rod, and with the coloured spectrum falling upon coloured bodies. Many changes and improvements in this theory have been made, particularly in regard to the number of simple coloured rays, which some have reduced to three, and others to two.

COLOURING; one of the essential parts of painting. Besides a knowledge of the art of preparing and mixing colours, and the whole mechanical process, from the beginning to the finishing of a picture, which, in the various kinds of painting, varies according to the materials of each, colouring comprehends the knowledge of the laws of light and colours, and all the rules deducible from the observation of their effects in nature, for the use of the artist. This subject has been treated by Leonardo da Vinci, in his work on painting; Lomazzo and Gerard Lairesse, in books on the same subject; Mengs, in his *Praktischer Unterricht;* Goëthe, in his *Farbenlehre*, &c.

The skill of the painter presupposes a natural ability, founded on superior sensibility, viz. the ability to image forth, and in the imitation, to express with characteristic truth, the peculiar substance and colour of any object under the influences of the light and air. To make this imitation successful, an accurate attention to the local tones and tints is requisite. By *local tones* we understand the natural colour of an object as it appears on the spot where it stands, or from the spot where the spectator is supposed to be stationed. In works of art, the natural colour of an object appears always as a local tone, because every object must be regarded from only one point of view; conformably to which the natural colour is modified according to the supposed distance. By *tints* we understand, in a more restricted sense, the gradations of the clear and obscure, which lights and shadows produce on the coloured surface. In no object of art do these modifications and shades exist in greater delicacy and diversity than in the naked human body, which is, consequently, the most difficult subject for a painter. Colouring, in as far as it is an imitation of the colour and character of flesh (the naked body), is called *carnation*.

If, in addition to the accurate coincidence of the natural colours, local tones, and tints of a painting, with its original, the artists hits the expression of the peculiar character of the substance of which the object consists, the colouring is called *true*. But to truth should be joined beauty, which is attained by the harmonious union of all the tones of the painting into one leading tone. The colouring must conform to and promote the object of the painting, as a work of art, and by the harmony of the colours and lights, as well as by the truth of the local colours, and of the individual parts of the subject, constitute one beautiful whole. In the choice of lights and the distribution of colours, the artist should aim, not only at clearness of representation, but at the same time, at the production of a pleasing harmony, which should aid the general impression of the piece. Consequently, *keeping*, and *chiaro scuro* are comprehended in the idea of correct, beautiful colouring.

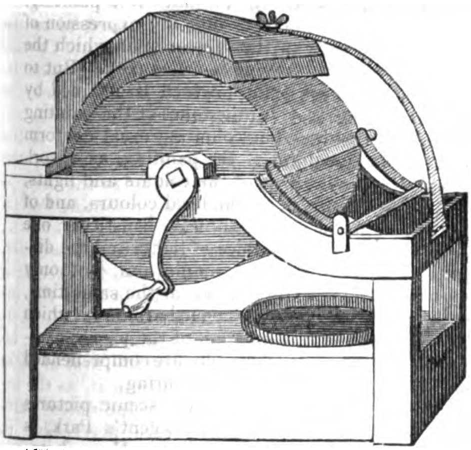
The mode of colouring the great scenic pictures exhibited at the Diorama, in the Regent's Park, is deservedly the subject of admiration. Here, however, the skill of the optician is united to that of the colourist. The light is admitted through various mediums of different tints, and by this ingenious contrivance the accuracy of nature is given to a perfectly flat surface. It may be proper to add, that the varying tints adapt themselves to the character of morning and sunset, and the passage of the clouds is perfectly delineated on the scene.

Colours are earthy and metallic bodies, which require a very intimate blending before they can be employed advantageously by the artist. This is effected both by dry and moist grinding.

The grinding of colours is usually attended with much danger to the labourers employed in that

branch of the process. A mode of diminishing this inconvenience is exhibited in the engraving.

Now, if we suppose the workman to be grinding at the stone beneath, the upward current for carrying off the deleterious vapour, is formed by a fire-place above the hood. A similar process might be advantageously adopted in the pointing of needles; and many other trades. Indeed it is the basis of all scientific ventilation, and has been usefully applied on the large scale in most of our great theatres—the chandelier serving the purpose of a fire-place.



The engraving of the cylindrical mill, represented above, with its hopper, for supplying colour as it is required by the stone, is too simple to need a particular description.

Colossi. The practice of executing statues of colossal dimensions and proportions, is of very high antiquity. The people of the East, from the most ancient times, have been celebrated for colossal sculpture. The pagodas of China and of India, and the excavated caverns of the East, abound with *colossi* of every denomination. The Asiatics, the Egyptians, and in particular the Greeks, have excelled in these works. The celebrated colossus of Rhodes was reckoned one of the seven wonders of the world. This statue, which Muratori reckons among the fables of antiquity, was raised by the Rhodians, in honour of Apollo.

There are many contradictory accounts in ancient authors concerning this colossal statue of Apollo; but the following, gathered from several sources, is not devoid of interest, though mixed up with much fable. When Demetrius, king of Macedon, the son of Antigonus, laid siege to the city of Rhodes, because the Rhodians would not renounce their alliance with Ptolemy Soter, they were succoured by their allies, and particularly by Ptolemy, so effectually, that the besiegers were compelled to abandon their enterprise. The Rhodians, in recognition of their regard for these services of their allies, and of the protection of their tutelary deity, Apollo, resolved to erect a brazen statue of the sun of prodigious size. Chares, the disciple of Lysippus, was intrusted with the project. He had scarcely half finished the work, when he found that he had expended all the money that he had received for the whole, which overwhelmed him so completely with grief and despair, that he hanged himself. Laches, his fellow-countryman, finished the work in the space of three Olympiads (twelve years), and placed the enormous statue on its pedestal. Pliny does not mention the latter artist, but gives all the honour to Chares.

Scarcely sixty years had elapsed before this monster of art was thrown from its place by an earthquake, which broke it off at the knees; and so it remained till the conquest of Rhodes by the Saracens, in A. D. 684, when it was beaten to pieces, and sold to a Jew merchant, who loaded above 900 camels with its spoils. Strabo, Pliny, and other ancient authors, who lived at the time that the colossus of Rhodes is said to have been in existence, and who could have learned from contemporaries the truth or falsehood of the accounts of it, give its height at 70 cubits, or a hundred English feet. Other authors, who flourished since its destruction, report its height at 80 cubits. Pliny also relates other particulars, as that few persons could embrace its thumb, and that its fingers were as long as ordinary statues, which, calculated by the proportion of a well-made man, would make its height nearer to 80 than 70 cubits. Perhaps the latter dimension may relate to its real altitude to the crown of its head, and the greater to its altitude if erect. The statue was placed across the entrance of the harbour, with its feet on two rocks; and the Rhodian vessels could pass under its legs. Some antiquaries have thought, with great justice, that the fine head of the sun, which is stamped upon the Rhodian medals, is a representation of that of the colossus.

One of the largest colossal figures in the world is the *Sphynx*. It is in the midst of a vast ocean of sand, and facing the second great pyramid on the eastern side. Its present appearance is represented beneath.

Sphynxes appear to have been used by the Egyptians, to show the beginning of the waters' rising in

the Nile: with this view, as it had the head of a woman and body of a lion, it signified that the Nile began to swell in the months of July and August, when the sun passes through the signs of Leo and Virgo.

From the deep interest which the Egyptians felt in this mighty river, the hieroglyphical representations in the sphynx were multiplied to a great extent. There is little more than the top of the great sphynx visible, which is more than 100 feet long. It is of one single stone, making part of the rock on which the pyramids are placed. Its head rises about twenty-nine feet above the sand. This, according to Thevenot, is twenty-six feet high, and fifteen feet from the ear to the chin; but Pliny assures us, the head was no less than one hundred and two feet in circumference, and sixty-two feet high from the belly, and that the body was one hundred and forty-three feet long, and was thought to be the sepulchre of king Amasis.

Some have suggested, that the well of the great pyramid led to this monster, and that the priests resorted thither at certain times to pronounce their oracles; alleging that a hole placed at the top of the sphynx's head answered for some deceptive purpose; but this hole is only five feet deep, and communicates neither with the mouth nor with the inside of the colossal monster. The Arabs, who have a holy horror of all representations of men and animals, have disfigured its face with arrows and lances, which has acted much more than time upon the stone.

The learned Mr. Bryant observes, that the sphynx seems to have been originally a vast rock of different strata; which, from a shapeless mass, the Egyptians fashioned into an object of beauty and veneration. It may hardly be necessary to add, that the features are of the Coptic cast.

Of other colossal statues, those which were executed by Phidias are among the most celebrated for beauty and elegance of workmanship. They were his Olympian Jupiter and his Minerva of the Parthenon. The virgin goddess was represented in a noble attitude, 26 cubits or 39 feet in height, erect, clothed in a tunic reaching to the feet. In her hand she brandished a spear, and at her feet lay her buckler and a dragon of admirable execution, supposed to represent Erichthonius. On the middle of her helmet a sphynx was carved, and on each of its sides a griffin. On the ægis were displayed a Medusa's head and a figure of Victory. This colossal work was not only grand and striking in itself, but contained, on its various parts, curious specimens of minute sculpture in *basso rilievo*, which Phidias is said to have brought to perfection.

His Olympian Jupiter was executed after the ungrateful treatment that he received from the Athenians, when he abandoned the city of his birth, which he had rendered celebrated by his works, and took refuge in Elis. Animated rather than subdued by the ingratitude of his countrymen, Phidias laboured to surpass the greatest works with which he had adorned Athens. With this view he framed the statue of Jupiter Olympius for the Eleans, and succeeded even in excelling his own Minerva in the Parthenon. This colossal statue was 60 feet in height, and completely embodied the sublime picture which Homer has given of the mythological monarch of the heavens.

While describing the *colossi* of ancient times, we should not forget the magnificent and extravagant proposal of Dinocrates to Alexander the Great, of forming Mount Athos into a colossus of that conqueror; nor a similar proposal, in modern times, of sculpturing one of the Alps, near the pass of the Simplon, into a resemblance of Napoleon. Among other celebrated *colossi* of ancient times, historians record as eminently beautiful, that which was executed by Lysippus at Tarentum. It was 40 cubits or 60 feet in height. The difficulty of carrying it away, more than moderation in the conqueror, alone prevented Fabius from removing it to Rome, with the statue of Hercules, belonging to the same city. *Colossi* were in use also in Italy before the time when the Romans despoiled their vanquished enemies of their works of art. The Jupiter of Leontium, in Sicily, was 7 cubits in height, and the Apollo of wood that was transported from Etruria, and placed in the palace of Augustus, at Rome, 50 feet.

The same emperor also placed a fine bronze colossus of Apollo in the temple of that god, which he built near his own palace. The earliest colossus recorded to have been sculptured in Rome was the statue of Jupiter Capitolinus, which Spurius Carvilius placed in the capitol after his victory over the Samnites; but *colossi* soon became far from scarce. Five are particularly noticed; namely, two of Apollo, two of Jupiter, and one of the sun. There has been dug up, among the ruins of ancient Rome, a colossal statue of the city of Rome, which was reckoned among the tutelary divinities of the empire. The superb *colossi* on the Monte Cavallo, called by some antiquaries the *Dioscuri*, are magnificent specimens of Grecian art; so are the Farnese Hercules and the gigantic Flora of the Belvedere. It used to be the common opinion, that the *colossi* on Monte Cavallo both represented Alexander taming Bucephalus. They are now generally believed to represent the *Dioscuri* Castor and Pollux; the statue which, according to the inscription on the pedestal, is the work of Phidias, being intended for Castor; the other, of inferior value, and, according to the inscription, the production of Praxiteles, representing Pollux. The original design of these statues is not known; nor does it appear from history what led Praxiteles, after an interval of about 80 years, to execute a counterpart to the work of Phidias, in case the inscription is to be credited. The editors of Winckelmann's works (vi. 2d part, p. 73, and v. p. 560), on account of the elevated character of the first of these statues, think it reasonable to attribute it, as the inscription does, to Phidias; for in the individual parts there is no narrow, laboured care perceptible in the execution, no overwrought polish and elegance. From various inequalities on the statue of the man—for instance, on the chin—they conjecture that this work was not completed by that great master, and hence was not esteemed so highly at first as afterwards, when the era of noble Grecian sculpture had passed away, and when the statue was probably first set up. But, as the primitive design of the work required a counterpart, they conjecture that the sculpture was committed to Praxiteles, the most perfect artist of that period.

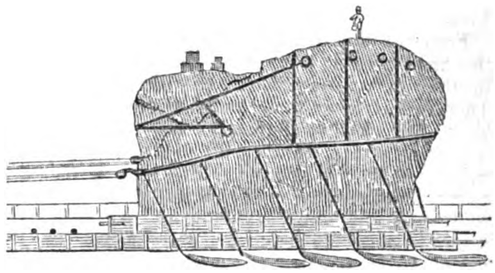
On this hypothesis, they explain the marks of a later age in the second statue, particularly the great dexterity with which the master has imitated the first, and finished every part without seeming to be a

mere copyist. The want of that lofty spirit which distinguishes the earlier statue they ascribe to the constraint of the artist in forming a counterpart to a previous work, and to the circumstance that Praxiteles, belonging to an age which was fond of the gentle and soft, entered the lists with the giant of an earlier period in the arts. Canova has attempted to prove, from the nature of the groups, that in both, the hero and horse were so placed that the two could be seen at once; and perhaps it was so originally; but the horse is now exactly opposite to the spectator, and the whole is less agreeably grouped. Rome possesses several other *colossi*, of admirable workmanship, as the colossal statue of Alexander the Great, in the Colonna palace; the rare colossus of Antoninus, in the Palazzi Vitelleschi; the celebrated statue of the Nile; the four statues that surround the splendid fountain and obelisk of the Piazza Navona, the admired work of Bernini. They are personifications of four of the principal rivers in the world; namely, the Ganges, which was sculptured by Fran. Baratta; the Nile, by Antonio Fancelli; the Danube, by Claude Franc; and the Rio de la Plata, by Antonio Raggi. Other colossal statues of less consequence are also found among the beautiful works of art in this city.

The pride and ambition of the Roman emperors led them to encourage sculptured representations of their persons. Nero was the first who ventured on a colossus of himself, by Zenodorus; but, after his death, it was dedicated to Apollo or the sun. Commodus afterwards took off the head, and replaced it with a portrait of himself. Domitian, actuated by a similar ambition, prepared a colossus of himself as the deity of the sun. Among more modern works of this nature is the enormous colossus of San Carlo Borromeo, at Arona, in the Milanese territory. It is of bronze, 60 feet in height, and has a staircase in its interior, for the purpose of occasional repairs and restorations.

The bronze colossus, copied from one of the Monte Cavallo statues, in Hyde Park, London, and a few but little larger than life, of the size that may be termed *heroic* rather than *colossal*, such as decorate some public buildings and commemorative columns, as those on St. Paul's Cathedral; William Pitt, in Hanover Square; the Duke of Bedford, in Russell Square; Charles Fox, in Bloomsbury Square, &c., are the principal of which we now boast in this noble style of art. The four colossal statues at Paris, which are in front of the façade of the *Corps Législative*, are in good taste, and show great boldness and freedom in the execution. They represent the four greatest legislators of France—Sully, Colbert, L'Hopital, and D'Aguesseau. They are in their proper costume, and seated. Canova's Perseus is also much larger than life, and a very fine work. They belong rather to the heroic than the colossal.

The enormous weight of many of the ancient as well as modern *colossi*, has very materially increased the difficulty of their erection. We may take a single example, namely, that of the statue of Peter the Great at St. Petersburg. The base alone weighed 400,000 lbs., and yet it was transported many miles both by sea and land. In the first of these cases it was conveyed between two frigates, and in the second its transit was accomplished by the aid of friction-balls. The accompanying engraving will give a general notion of the process. Two vast beams grooved to receive the friction-balls were placed beneath each of the sides of the stone, and capstans worked by several men, each were employed to give



motion to the mass. On the top of the stone was placed a drummer, by whose instrument the combined efforts of the men were regulated. The small moveable stages attached by ropes, which are seen in the engraving, were used to convey the workmen and their tools along with the colossal stone.

Columbium. This metal was discovered in 1801, by Mr. Hatchett, who detected it in a black mineral, belonging to the British Museum, which was originally sent to Sir Hans Sloane by Governor Winthrop, of Connecticut, and was supposed to have been found near New London in that state. About two years after M. Ekeberg, a Swedish chemist, extracted the same substance from tantalite and yttro-tantalite, and, on the supposition of its being different from columbium, described it under the name of *tantalum*. The identity of these metals, however, was established in 1809 by Dr. Wollaston.

Columbium exists in its ores as an acid, united either with the oxides of iron, manganese, and tin, as in the columbite or tantalite; or in combination with the earth yttria, as in the yttro-columbite, or yttro-tantalite. This acid is obtained by fusing its ore with three or four times its weight of carbonate of potash, when a soluble columbate of that alkali results, from which columbic acid is precipitated as a white hydrate by acids. When this acid is exposed to the united agency of charcoal and intense heat, it is reduced to the metallic state.

The metal is brittle, of an iron-gray colour, and feebly-metallic lustre. Its specific gravity is 5.6. It is not attacked by the nitric, muriatic, or nitro-muriatic acids, but is converted into the acid by being heated with potash or nitre. Columbium has hitherto been obtained in very minute quantities, and has never been applied to any economical purpose. Columbite, the ore from whence it is obtained, has of late been discovered in several places in New England.

Column (*columna*, Lat.), in architecture, a round pillar. In the earliest periods of the world the column was merely the trunk of a tree, or its imitation in stone, used to support the roof. The parts of a complete column are its *base*, on which it rests, its body, called the *shaft*, and its head, called the *capital*. Columns are used to support the entablature of an order, which has also its proper division. In the most ancient times columns of wood were the most usual, as being the most easily wrought. In countries like Egypt, where timber fit for construction is scarce, and stone abundant, the latter became the principal material for columns; and those of Egypt

are remarkable for the beauty of their workmanship, and the durability of their materials.

The Greeks used marble of the finest kind, with which their country abounded, for their columns; and other nations, the stone or material of their country. The Greeks properly considered the column as an essential part of the architecture of their temples, and never used it as a mere decoration. The manner of constructing the columns of all the orders rests upon similar principles. They are all divided into three primary parts or divisions, the base, the shaft, and the capital, except the Doric order, which has no base. The lowest or thickest part of the shaft is used by architects as the universal scale or standard whence all the measures which regulate and determine heights and projections are taken; and this standard or scale must be understood before any architectural design can be commenced.

The relative proportions of the various species of column has already been given in our article illustrative of general architecture.

We have now to notice the employment of columns as *trophies*. The Romans had their *columna bellica*, which was near the temple of Janus, and from which war was proclaimed by the consul casting a javelin from it towards the country of their enemy; also *chronological columns*, whereon they inscribed historical events according to the order of time.

They had also a *lacteal column*, which was erected in the vegetable market, and contained in its pedestal a receptacle for infants that were abandoned by their parents. The *legal column* was one on which the ancients engraved their laws; the *limitative* or *boundary column* marked the boundary of a state or province; the *manubial column* was ornamented with trophies and spoils taken from the enemy; the *rostral column* with the prows (*rostra*) of the ships obtained in a similar manner. The first column of this description was that which was erected in the capitol, on the occasion of the naval victory which Caius Duilius obtained over the Carthaginians. It is now on the balustrade of the grand staircase of the Campidoglio. Augustus raised four, decorated with the prows of the vessels which were taken from Cleopatra. Two were also erected to the honour of Caius Menius, for a naval victory over the Latins and Antiates.

The *sepulchral column* was elevated upon a sepulchre or tomb, with an epitaph engraved upon its shaft. The *triumphal column* was erected by the Romans in commemoration of a conqueror to whom had been decreed the honours of a triumph. The joints of the stones were concealed by crowns obtained by military conquests. The columns of Trajan and Antonine, besides their specific objects, are also triumphal columns.

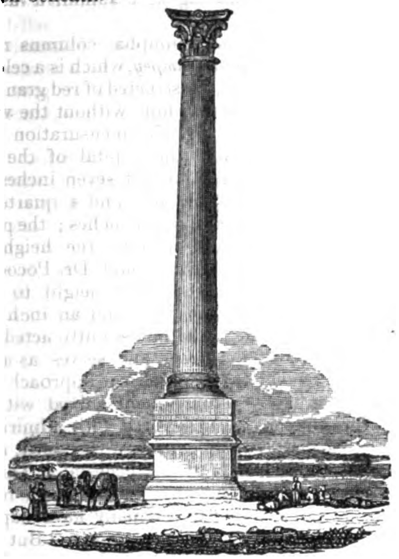
The British Parliament, when they voted the magnificent palace of Blenheim to the great Duke of Marlborough, also erected a triumphal column in the park. On the four sides of the pedestal are inscribed descriptions of the victories of that great commander; and his statue is upon the abacus, supported by figures of captured enemies, and surrounded by trophies.

The *military column*, or *milliarium aureum*, of Rome, was originally a column of white marble, which Augustus erected near the temple of Saturn, in the forum, as a centre whence the account of the miles began in the calculation of distances from the city. This celebrated column is still in existence, being placed on the stylobate in front of the Campidoglio, the modern capitol of Rome. It is a short column, with a Tuscan capital, and has a ball of bronze, as a symbol of the globe. It was called *golden*, either because it was once gilded all over, or at least the globe and ornamental accessories. As a companion to it is a similar column, bearing on its summit a vase, containing the ashes of Trajan.

Among the principal triumphal columns now remaining is the column of *Pompey*, which is a celebrated monument of antiquity, constructed of red granite, and situated on a rock, about a mile without the walls of Alexandria, in Egypt. By the mensuration of Edward Wortley Montagu, the capital of the pillar, which is Corinthian, is nine feet seven inches high; the shaft sixty-six feet one inch and a quarter; the base five feet nine three-quarter inches; the pedestal ten feet five and a half inches; the height from the ground ninety-two feet: though Dr. Pococke, by the shadow, determined the whole height to be 114 feet; and its diameter nine feet and an inch. It is perfectly well polished, and but slightly acted on by time. It overtops the town, and serves as a signal for vessels. Savary says, on a near approach it produces a degree of astonishment mixed with awe. The spectator can never be tired with admiring the beauty of the capital, the length of the shaft, nor the extraordinary simplicity of the pedestal. This prodigious mass stands, as on a pivot, on a reversed obelisk; and was erected, as many have supposed. either by Pompey, or to his honour. But as no mention is made of it by Strabo, Diodorus Siculus, or any other ancient writers, Mr. Montagu concludes that it was not known before the time of Vespasian, and that it was created to his honour. In proof of this opinion, he found within the circumference of the pillar a medal of Vespasian, in fine preservation.

Savary, on the authority of Abulfeda, who calls it "the pillar of Severus," ascribes it to this emperor; alleging that he visited Egypt, gave a senate to Alexandria, and deserved well of its inhabitants. Accordingly, it is said, that this column is a mark of their gratitude. The Greek inscription, now more than half effaced, was, no doubt, legible in the time of Abulfeda, and preserved the name of Severus. Nor is this the only monument erected to him by the gratitude of the Alexandrians. In the midst of the ruins of Antinoe, built by Adrian, is seen a magnificent pillar, the inscription on which is still remaining, dedicated to Alexander Severus. Denon has given a drawing of this pillar, with the marked dimensions of its various parts: it makes its whole height a fraction more than 92 feet, and the height of the shaft, which is of a single piece, 63 feet 1.3. It acquired, as this author says, the name of Pompey's Pillar in the 15th century. A monument, as he supposes, had been raised by Pompey at Alexandria, but it had disappeared, and was thought to be discovered in the above column, which has since been converted into a trophy erected to the memory of Septimius Severus. It is, however, placed on the ruins of the ancient city; and, in the time of Septimius Severus the city of the Ptolemies was not in a ruinous state. If the shaft of this column, continues Denon, once belonged to an ancient edifice, it is an evidence of its magnificence, and of the skill with which it was executed. It ought therefore to be said, that what is called Pompey's Pillar is a fine column, and not a fine monument, and that a column is not a monu-

ment. In consequence of the earth about the foundation of this pillar having been cleared away, two fragments of an obelisk of white marble, the only monument of that substance seen by Denon in Egypt, have been added to the original base, to render it more solid. An engraving of this celebrated column is given beneath.



The *Trajan column* is one of the most celebrated monuments of antiquity. Its height, including the pedestal and statue, is 132 feet. This monumental column was erected in the centre of the forum Trajani, and dedicated to the Emperor Trajan for his decisive victory over the Dacians, as is testified by the inscription on the pedestal. It is of the Doric order, and its shaft is constructed of 34 pieces of Greek marble, joined with cramps of bronze. For elegance of proportion, beauty of style, and for simplicity and dexterity of sculpture, it is the finest in the world. The figures on the pedestal are masterpieces of Roman art. It was formerly surmounted by a statue of Trajan, which has been succeeded by a statue of St. Peter.

The *column of the Emperor Phocas* is near the Temple of Concord. It is of Greek marble, fluted, and of the Corinthian order, four feet diameter, and fifty-four feet high, including the pedestal. The *Antonine column* was erected by the Roman senate to the glory of Marcus Aurelius, for his victories over the Marcomanni, in the reign of Commodus. Aurelius afterwards dedicated it to his father-in-law, Antoninus Pius. According to a rigid admeasurement, made by M. de la Condamine, this column is 116 French feet in height, and 11 in diameter. It is built entirely of marble, and encircled with *bassi rilievi*, which form 20 spirals around its shaft. It has been well illustrated by engravings and descriptions by Pietro Santi Bartoli. It is in every respect inferior to that of Trajan as a work of art, particularly in the style and execution of the sculptures. It was repaired in 1589 by Fontana, under the pontificate of Sixtus V., who placed a colossal statue of St. Paul upon its summit.

There is also in Rome another column bearing the same name, situated on the Monte Cittorio. Its shaft is of a single piece of Egyptian granite, 45 feet in height, and 5 feet eight inches in diameter. Its pedestal is ornamented with *bassi rilievi*, representing the apotheosis of Antoninus and Faustina, and other events relating to the history of Rome. It was repaired by Lambertini. Pius VI. removed the *bassi rilievi* to the Vatican. There is an engraving of it in the 5th volume of the *Museo Pio-Clementino*. On one of its sides it has the following inscription:—"Divo Antonino Avgvstino pio Antoninvs Avgvstvs et Vervs Avgvstvs filii." Till the commencement of the 18th century, there were to be seen at Constantinople two insulated columns, ornamented with *bassi rilievi*, in the style of the Trajan column at Rome. One was erected in honour of Constantine, and the other of Arcadius or Theodosius. Of the latter there is nothing left but its granite base, the column having been destroyed by the Turks. It had been several times damaged by earthquakes, and they were fearful of its falling. The *Constantine column* was composed of seven large cylindrical blocks of porphyry, and was originally surmounted by a statue of Constantine. After having been several times damaged by fire, it was repaired by the Emperor Alexis Comnenus, as is indicated by an inscription in Greek.

The column which ornaments the British metropolis, better known as the *Monument*, was designed by Sir Christopher Wren, and erected by order of parliament, in memory of the burning of the city of London, anno 1666, in the very place where the fire began. This pillar was begun in 1671, and finished in 1677.

It is of the Doric order, fluted, 202 feet high from the ground, and fifteen feet in diameter, of solid Portland stone, with a staircase in the middle, of black marble, containing three hundred and eighty-five steps. The lowest part of the pedestal is 28 feet square, and its altitude 40 feet; the front being enriched with curious *bassi rilievi*. It has a balcony within 32 feet of the top, on which is placed a blazing urn of gilt brass.

The column in *Phœnix Park*, Dublin, differs from any other work of this description. It was erected in 1745. It stands in the centre of an area where four great avenues meet, and from which there are entrances to the Vice-regal Lodge, and that of the chief secretary. The trees which shade the avenues form vistas, through which the perspective view of the column forms a picturesque object.

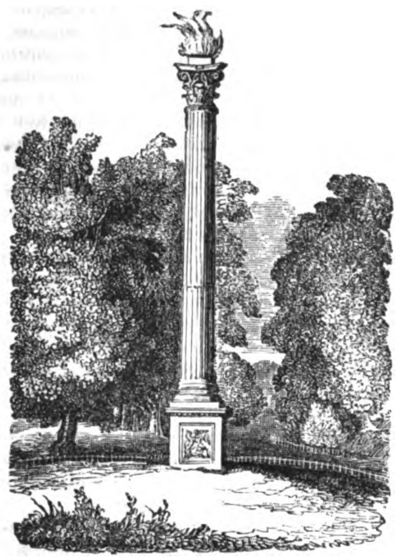
The pillar is formed of Portland stone, and is of the Corinthian order, fluted, and highly ornamented. The base and pedestal five feet in height, the shaft and capital twenty, and the phœnix which surmounts the column five feet, so that the whole presents an object thirty feet high. On the east and west sides of the pedestal are the following inscriptions:—

Civivm Oblectamento
Campvm Rvdem et Incvltvm
Ornari Ivssit
Philippus Stanhope,
Comes de Chesterfield
Prorex.

Impensis svis Posvit
Philippus Stanhope, Comes
De Chesterfield Prorex.

On the north and south sides are the crest and arms of Stanhope in relief. It is to be regretted, that from the perishable nature of the stone, this ornament to the park even already exhibits symptoms

of decay. To protect it from accidental violence, it has been enclosed by a circular iron railing; but this defence, while it keeps off the hand of man, cannot keep off the hand of time, which is fast obliterating its ornaments.



The *Napoleon column* has justly been considered as the greatest ornament of the Parisian capital. It stands in the Place Vendome, and was erected to commemorate the successful result of Bonaparte's arms in the German campaign of 1805.

Its total elevation is 135 feet, and the diameter of its shaft is twelve feet. It is in imitation of the pillar of Trajan at Rome, and is built of stone, covered with bas-reliefs (representing the various victories of the French army), composed of twelve hundred pieces of cannon taken from the Russian and Austrian armies. The bronze employed in this monument was about three hundred and sixty thousand pounds weight. The column is of the Doric order. The bas-reliefs of the pedestal represent the uniforms and weapons of the conquered legions. Above the pedestal are festoons of oak, supported at the four angles by eagles, in bronze, each weighing five hundred pounds. The bas-reliefs of the shaft pursue a spiral direction from the base to the capital, and display in chronological order the principal actions of the campaign, from the departure of the troops from Boulogne to the battle of Austerlitz. The figures are three feet high; their number is said to be two thousand, and the length of the spiral band eight hundred and forty feet. Above the capital is a gallery, which is approached by a winding staircase within, of one hundred and seventy-six steps. It has the following inscription:

Monument élevé a la glorie de la grand armeé.
Par Napoleon Le Grand
Commencé le xxv Août 1806,
Terminé le xv Août 1810.
Sous la direction de D. V. Dénon.
MM. J. B. Lepére et L. Goudoin, architectes.

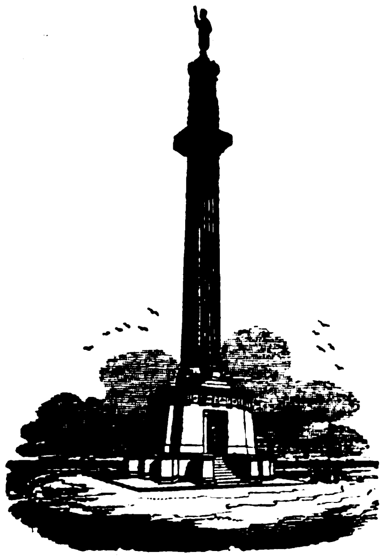
Over the door leading to the staircase is a bas-relief, representing two figures of Fame supporting a tablet.

The capital of the column is surmounted by an acroterium, upon which formerly stood the statue of Napoleon, measuring eleven feet in height, and weighing five thousand and twelve pounds. The platform upon which it rests is of white marble, surmounted with palisades. Some of the most beautiful portions of this column, or rather of its *bas relief* ornaments, were designed by a young and self-taught female artist; a lady who, but for the deposition of Napoleon, would in all probability have attained the highest and most lucrative walks in her profession. The total expense of this sumptuous monument was 1,500,000 livres.

There are also several smaller columns, but of beautiful proportions, in various parts of England, in imitation of the above, but mostly of the Grecian or pure Doric order, as the Anglesea column, erected in commemoration of the battle of Waterloo, and the noble earl of that name, in the island of Anglesea; the column at Shrewsbury, erected in commemoration of the same event, and of another noble general, Lord Hill; the Nelson columns, at Yarmouth and in Dublin; the Wellington column, at Trim, in the county of Meath, Ireland, &c.

To the above list, we may add the *Washington monument*, at Baltimore, on which a colossal statue of Washington has been placed. The pillar is of the Grecian Doric order, and of very massive proportions. It stands on a grand base or zocle, and is surmounted by a circular pedestal, on which the statue rests. This base or zocle of the monument is 50 feet square, and 25 feet high; the column is 20 feet in diameter, and with its sub-base, 130 feet high; the capital is 20 feet square. The statue is 15 feet high, and the whole height of the monument, from the pavement, including the statue, will be 176 feet. As it stands on a hill 100 feet high, this structure rises 276 feet above tide. It is constructed of white marble, which is slightly variegated, and is a very conspicuous object to every one approaching the city, whether by land or water. The statue greatly increases its effect, and gives finish and beauty to the whole structure. A flight of steps, on each side of the grand base, leads up to the door-way. A broad frieze runs round the exterior of the grand base, with a series of civic wreaths, each encircling a star, to designate the states of the Union. In the centre of the frieze, above the door-ways, are large marble tablets, inscribed with the name of Washington. Bronze inscriptions, commemorative of events in the revolution connected with the life of Washington, are placed on every front of the base. The base of the column above the great platform is encircled with thirteen colossal bronze shields, emblematic of the federal union; the faces of the shields are ornamented with the arms of those states which formed the federal compact, divided by massive spears. The attitude given to the statue represents the great man to whom the monument is dedicated in the act of resigning his commission, and the authority with which he had been invested by his country, again into the hands of the people, having accomplished the great object of his appointment—the freedom and independence of the Union. The marble of which the statue is formed is of a very pure kind, free from veins, and is a fine specimen of the native white formation which abounds in the neighbourhood of Baltimore. The statue, the work of Mr. Causici, weighs 16½ tons.

The column erected to the memory of Lord Nelson, on the *Denes*, at Yarmouth, was completed in 1817, and forms a *sea-mark* visible at an immense distance. It is represented beneath.



The following translation of the Latin inscription by Serjeant Frere, will best explain the object of this beautiful column:—

"HORATIO LORD NELSON,

whom, as her first and proudest champion in naval fight, *Britain* honoured, while living, with her favour, and, when lost, with her tears; of whom, signalized by his triumphs in all lands, the *whole earth* stood in awe, on account of the tempered firmness of his counsels, and the undaunted ardour of his courage. This great man *Norfolk* boasts her own, not only as born there of a respectable family, and as there having received his early education, but her own also in talents, manners, and mind. The glory of so great a name, though sure long to outlive all monuments of brass and stone, his fellow-countrymen of Norfolk have resolved to commemorate by this column, erected by their joint contributions. He was born in the year 1758, entered on his profession in 1771, and was concerned in nearly 150 naval engagements with the enemy; being conqueror, among various other occasions, at Aboukir, August, 1798; at Copenhagen, April, 1801; and at Trafalgar, October, 1805; which last victory, the crown of so many glorious achievements, he consecrated by a death equally mournful to his country and honourable to himself."

COLUMN, in *tactics*; a deep, solid mass of troops, formed by placing several bodies of men behind each other (sections, platoons, companies, squadrons, and even several battalions). The column is either an open or a close one (with intervals, or having the sections close behind each other): it may be formed either for marching or for attack. By means of columns, it is possible to march in places where it would be impracticable to move with unbroken lines. They also increase the force and steadiness of troops, both in attack and defence. The drawing up of the infantry in line is advisable, where there is no obstacle in the ground to prevent advancing in this order, or when the enemy is to be received with the fire of musketry, and where cannon-balls and grenades are more to be feared than case-shot and musketry.

Almost all battles are fought, at present, by small columns, which, when the order in line is judged more for the purpose, may be changed into lines, and which, besides, form the best squares for resistance against attacks of cavalry, by presenting a front to all sides, and unite many other advantages. In the case of cavalry, also, attacks may be made either in column or in line. The charge in close columns, which is in use particularly with the French, is of the greatest effect when it succeeds; but when it fails, the whole body of assailants is exposed to annihilation or to rout, as no support, no developement, nor orderly retreat is possible.

The attack with columns at some distance from each other has this advantage, that if the first division fails, the subsequent ones may succeed; moreover, the facility of manœuvring is much greater. This mode of attack is particularly advisable in assaulting squares of infantry. Marching and fighting in lines, however, are the modes usually practised by cavalry.

COMBINATION, in *Mathematics*, is the variation or alteration of any number of figures, letters, colours, sounds, &c., in all the different manners possible. The parts combined are called *elements*.

The *doctrine of combination* is that branch of mathematics which teaches the mode of acquiring the results arising from all possible combinations, and gives rules respecting them.

Combinatory analysis is the application of the doctrine of combination to analysis, and constitutes a branch of science often very involved. A system of characters is appropriated to this purpose. Hindenburg, of Leipsic, in 1778, gave it the character of an independent science; and it has been of important service in relation to the higher branches of mathematics.

COMBUSTION. It is not easy to give a correct definition, or to assign a general cause, of this familiar phenomenon. It may, however, be described as the result of the combination of two or more bodies, attended with a disengagement of heat and light. This description distinguishes *combustion* from *ignition*, which is merely the result of an elevation of the temperature, without any chemical combination. Fire was formerly considered as an element, which had the power of converting certain bodies into its own nature; but the progress of chemical science soon showed the error of this notion. Stahl's celebrated theory was founded on the hypothesis of the existence of a substance which he called *phlogiston*.

Every combustible body was supposed to contain this substance, which was disengaged by combustion: the loss of the phlogiston was the cause of the residuum being incombustible. The heat and light were attributed to the violent agitation of the phlogiston at the moment of its disengagement. The discoveries of Black and Priestley opened the way to the system of Lavoisier, which, in 1785, entirely supplanted the theory of Stahl. During the conversion of solids into fluids, and of fluids into vapours, there is a considerable absorption of heat: when, on the contrary, vapours and liquids are restored to the fluid and solid form, the heat which they contain is evolved, and passes from the latent to the sensible state.

These views were assumed by Lavoisier as the basis of his theory.

Oxygen gas was considered as a compound of a peculiar basis, united to the matter of light and heat, and combustion as the combination of oxygen with the burning body. During the combustion, the basis, combining with the combustible, augmented its weight and changed its properties; while the imponderable elements of the gas—light and heat—were developed in the form of flame. But facts prove this theory incorrect. In the first place, all the phenomena of combustion take place, in many cases, without the presence of oxygen. In the second place, there are many cases in which oxygen unites with bodies, without the evolution of light and heat, as during the change of some metals on exposure to the air. And, farther, there are many instances in which combustion takes place not only without condensation, but where gaseous matter is actually produced from solid matter, as in the inflammation of gunpowder. Besides, the evolution of light, if it were derived from the gas, should be proportional to the quantity solidified, whereas it depends chiefly on the combustible.

The first of these objections to Lavoisier's theory, which is yet generally received, has been partly removed by modifying the definition so as to extend it to several other bodies, hence called *supporters of combustion*. The definition which we have given of this phenomenon at the beginning of this article is merely a description. The question arises, Whence come the light and heat? They are generally referred to the condensation which is almost always a necessary consequence of a chemical combination; but we have already seen that, in some cases, they are produced where the component parts actually pass from a solid to a gaseous state. It seems probable, in the present state of our knowledge, that they may be attributed to the disengagement of the electric fluid. "In every chemical combination," says Berzelius, "there is a neutralization of opposite electricities, and this neutralization produces the heat and light in the same manner as it does in the Leyden jar or the galvanic battery." But to this it may be objected, that if electricity were the cause of the disengagement of the heat and light, they would always bear a fixed proportion to each other. This is not the case: the combustion of oxygen and hydrogen disengages a very great quantity of caloric, but very little light; that of phosphorus and oxygen produces opposite results.

There is, then, no theory of combustion, at present received, which will explain all the circumstances of this phenomenon. If there be any one general cause, it must be one which, like affinity, is modified by the nature of the agents and the peculiar circumstances of their mutual action.

Combustion, Spontaneous. There is no subject connected with the animal economy and the theory of chemical change, which has excited so much attention as the one now before us. Volumes have been written on the subject of spontaneous combustion, and yet we are in possession of no satisfactory theory of its origin. The facts, however, which have been collected, are of so curious a character, as to warrant our preserving some of the best authenticated cases.

We read, in the *Transactions of the Society of Copenhagen*, that, in 1692, a woman of the lower class, who for three years had used liquors to such excess, that she would take no other nourishment, having sat down one evening on a straw chair to sleep, was consumed in the night-time, so that no part of her was found but the skull and the extreme joints of her fingers; "all the rest of her body," says Jacobus, "was reduced to cinders."

In the *Annual Register* for 1763, is published the following memoir by Bianchini: "The Countess Cornelia Bandini, of the town of Cesena, aged 62, enjoyed a good state of health. One evening, having experienced a sort of drowsiness, she retired to bed, and her maid remained with her till she fell fast asleep. Next morning, when the girl entered to awake her mistress, she found nothing but the remains of her body in the most horrid condition. At the distance of four feet from the bed was a heap of ashes, in which could be distinguished the legs and arms untouched. Between the legs lay the head, the brains of which, together with half the posterior part of the cranium remained, but the whole chin had been consumed. Two fingers had been found in the state of a coal, and the rest of the body reduced to ashes, which, when touched, left on the fingers a fat, fetid moisture. A small lamp which stood on the floor was covered with ashes, and had no oil. The tallow of two candles was melted on a table, but the wicks remained untouched, and the feet of the candlesticks were covered with a certain moisture. The bed was not damaged. The bed-clothes and coverlid were raised on one side, as is the case when a person gets up. The furniture and tapestry were covered with a moist soot, the colour of ashes, which had penetrated the drawers and soiled the linen. This soot having been conveyed to a neighbouring kitchen, adhered to the walls and the utensils; a piece of bread in the cupboard was covered with it, and no dog would touch it. The infectious odour had been communicated to other apartments." This account states that the Countess was accustomed to bathe all her body in camphorated spirits of wine.

In the same work, anno 1773, is given an account from Mr. Willman, a surgeon, of the death of Mary Clues, aged 50, who was much addicted to intoxication. "Her propensity to this vice had increased after the death of her husband, which took place a year and a half before. For about a year, scarcely a day had elapsed in which she did not drink half a pint of rum or aniseed. Her health gradually declined; when, about the beginning of February, she was attacked by the jaundice, and confined to her bed. Though she was incapable of much action, and not in a condition to work, she still continued her old habit of drinking every day, and smoking a pipe of tobacco. The bed on which she lay stood parallel to the chimney of the apartment, and at a distance from it of about three feet. On Saturday morning, the 1st of March, she fell upon the floor, and her extreme weakness having prevented her from getting up, she remained in that state until some one entered, and put her to bed. The following night she wished to be left alone. A woman quitted her at half-past eleven, and, according to custom, shut the door and locked it. She had put on the fire two large pieces of coal, and placed a light in a candlestick on a chair at the head of her bed. At half-past five in the morning, a smoke was seen issuing through the window, and the door being broke open, some flames which were in the room were soon extinguished. Between the bed and the chimney were found the remains of the unfortunate Clues. One leg and a thigh were still entire,

but there remained nothing of the skin, the muscles, or the viscera; the bones of the cranium, the breast, the spine, and the upper extremities were entirely calcined, and covered with a whitish efflorescence. The furniture had sustained but little injury. The side of the bed which was next the chimney had suffered most; the wood of it was slightly burnt, but the feather bed, the clothes, and covering, were safe. I entered the apartment about two hours after it had been opened, and observed that the walls and every thing in it were blackened, and that it was filled with a disagreeable vapour, but that nothing except the body exhibited any strong traces of fire."

An instance similar to this is related by Vicq. d'Azyr, in the *Encyclopædie Methodique*. A woman about fifty years of age, who indulged to excess in spirituous liquors, and got drunk every day before she went to bed, was found entirely burnt and reduced to ashes. Some of the osseous parts only were left, but the furniture of the room had sustained very little damage. The same author adds, that there have been many other instances of the same kind. We find also a circumstance of this kind in a work entitled *Acta Medica et Philosophica Hafniensia*, and in the work of Henry Bohenser, entitled *Le Nouveau Phosphore Enflammé*. A woman at Paris who had been accustomed for three years to drink spirits of wine to such a degree that she used no other liquor, was one day found entirely reduced to ashes, except the skull and extremities of her fingers.

The *Philosophical Transactions* contain an instance of human combustion no less extraordinary. Grace Pitt, the wife of a fishmonger in the parish of St. Clement, Ipswich, aged about sixty, had contracted a habit, which she continued for several years, of coming down every night from her bed-room, half dressed, to smoke a pipe. On the night of the 9th of April, she got up as usual: her daughter, who slept with her, did not perceive she was absent till next morning when she awoke. Soon after which she put on her clothes, and going down to the kitchen, found her mother stretched on the right side, with her head near the grate, her body extended on the hearth, with her legs on the floor, which was of deal, having the appearance of a log of wood consumed by fire without any apparent flame. On beholding this spectacle, the girl ran in great haste, and poured over her mother's body some water contained in two large vessels, in order to extinguish the fire; while the fetid odour and smoke which exhaled from the body almost suffocated the neighbours who ran to the girl's assistance. The trunk was in some measure incinerated, and resembled a heap of coals covered over with white ashes. The head, the legs, the arms, and the thighs had also participated in the burning. The woman, it is said, had drank a large quantity of spirituous liquor for joy, on learning that one of her daughters had returned from Gibraltar. There was no fire in the grate, and the candle was found entirely burnt out in the socket of the candlestick, which was close by her. Besides which, there were found near the consumed body, the clothes of a child and a paper screen, which had sustained no injury by the fire. The dress of this woman consisted of a cotton gown.

Le Cat, in a memoir on spontaneous burning, mentions several other instances of combustion of the human body. He lodged at Rheims, in 1725, at the house of Sieur Millet, whose wife was intoxicated every day. "The domestic economy of the family," he observes, "was managed by a pretty young girl, which I must not forget to remark, in order that all the circumstances which I am about to relate may be properly understood. This woman was found consumed on the 20th of February, 1725, at the distance of a foot and a half from the hearth in the kitchen. A part of the head only, with a portion of the lower extremities, and a few of the vertebræ had escaped combustion. A foot and a half of the flooring under the body had been consumed, but a kneading trough and a powdering tub, which were very near the body, had sustained no injury. M. Chretien, a surgeon, examined the remains of the body with every judicial formality. Jean Millet, the husband, being interrogated by the judges who instituted an inquiry into the affair, declared that about eight in the evening of the 19th of February, he had retired to rest with his wife, who not being able to sleep, had gone into the kitchen, for the purpose, he thought, of warming herself; that having fallen asleep, he was awakened about two o'clock by an infectious odour, and that having run into the kitchen, he found the remains of his wife in the state described by the physicians and surgeons. The judges having no suspicion of the real cause of the affair, prosecuted the inquiry with the utmost diligence. It was very unfortunate for Millet, that he had a *beautiful* maid servant, for neither his probity nor innocence was able to save him from the suspicion of having got rid of his wife by a concerted plot; and of having arranged the arts of the circumstance in such a manner as to give it the appearance of an accident. He experienced therefore the whole severity of the law; and although by an appeal to a superior and enlightened court, which discovered the cause of the combustion, he came off victorious, he suffered so much from uneasiness of mind, that he was obliged to pass the remainder of his melancholy days in a hospital.

The *Journal de Medicine*, vol. 59, p. 440, contains an account of a similar case related by M. Muraire, a surgeon, as occurring at the town of Aix, in Provence. "In the month of Feb. 1779, Mary Jauffret, widow of Nicholas Gravier, shoemaker, of a small size, exceedingly corpulent and addicted to drinking, having been burnt in her apartment; M. Rocas, my colleague, who was commissioned to make a report on the state of her body, found only a mass of ashes and a few bones, calcined in such a manner, that at the least pressure they crumbled into dust. The bones of the cranium, one hand, and a foot, had in some measure resisted the action of the fire. Near these remains stood a table untouched, and under the table a small stove, the grating of which having been long burnt, afforded an aperture, through which it is probable the fire, which occasioned the melancholy accident, had been communicated: one chair which stood near the flames had the seat and fore-feet burnt. In other respects there was no appearance of fire either in the chimney or the apartment; so that, except the fore-part of the chair, it appears to me, that no other combustible matter contributed to this speedy incineration, which was effected in the space of seven or eight hours."

Another case contained in the *Journal de Medicine* occurred at Caen, and is thus related by M. Merille, a surgeon of that place. Being requested on the 3d of June, 1782, by the king's officers to draw up a report of the state in which I found Mdlle. de Thuars,

who was said to have been burnt, I made the following observations:—The body lay with the crown of the head resting on one of the irons, at the distance of eighteen inches from the fire; the remainder of the body was placed obliquely before the chimney, the whole being nothing but a mass of ashes. Even the most solid bones had lost their form and consistence; none of them could be distinguished except the coronal, the two parietal bones, the two lumber vertebræ, and a portion of the tibia; and these even were so calcined, that they became dust by the least pressure. The right foot was found entire, and scorched at its upper junction; the left was more burnt. The day had been cold, but there was nothing in the grate except a few pieces of wood, about an inch in diameter, burnt in the middle; none of the furniture in the apartment was damaged. The chair on which Mdlle. Thuars had been sitting was found at the distance of a foot from her, and absolutely untouched. This lady was exceedingly corpulent; she was about 60 years of age, and much addicted to spirituous liquors; the day of her death she had drank about three bottles of wine and *one bottle* of brandy, and the consumption of her body had taken place in less than seven hours."

The case which we shall now relate was attended with circumstances of peculiar interest, because the unhappy man survived the accident some time, and gave an account of the various circumstances by which it was preceded and followed. The case was published in one of the journals of Florence, for October, 1776, by M. Battgalia, the surgeon who attended the unfortunate sufferer. Gio. Maria Bertholi, resident priest at Monte Volere, went on business to a neighbouring fair; and having spent the day in walking about the country, arrived in the evening at Jernielle, intending to sleep at the house of his brother-in-law. He was immediately on his arrival, at his own request, conducted to his chamber, when he had a handkerchief placed between his shirt and shoulders, and immediately commenced his devotions. But a few minutes had elapsed, when an uncommon noise, attended with cries, was heard issuing from his apartment. The people of the house were alarmed, and rushing in, found the priest stretched out upon the floor and surrounded by a light flame, which receded as they approached, and ultimately vanished. He was immediately placed in bed, and on the following morning visited by the surgeon, who, on examination, found the skin of the right arm and fore-arm detached from the muscles, and hanging loose. From the shoulders to the thighs the integuments were similarly injured. These detached portions of skin having been altogether removed, and mortification being perceived on the right hand, which had suffered most severely, the parts were scarified. Notwithstanding this precaution, it had fallen the next day into a state of gangrene. On the third day, all the other scorched parts were discovered to have degenerated into the same condition. The unhappy man complained of unquenchable thirst, and was horridly convulsed; the discharges from his mouth were putrid and bilious, and his strength was exhausted by continual vomitings, accompanied with delirium and a burning fever. After lying two hours in a state of insensibility, he expired on the fourth day. While he lay in this lethargic sleep, his attendant observed with astonishment that putrefaction had made considerable progress, so that the body exhaled an intolerable odour, and the nails were spontaneously detached from the fingers of the left hand. This unfortunate man informed the surgeon, that first of all he had felt a blow, like that inflicted by a cudgel, upon the right arm; and that at the same time he saw a light blue flame attach itself to his shirt, which was instantly reduced to ashes, yet his wristbands at the same time remained untouched. The handkerchief across his shoulders remained untouched. The lower part of his dress had escaped, but his cap was entirely consumed, although not a hair of his head had suffered by the flame. All the symptoms of the disease were those of a severe burn. The night of the accident was calm, and the atmosphere very clear; no empyreumatic smell, nor appearance of smoke was perceived in the chamber; but the lamp, before full of oil, was become dry, and its wick reduced to a cinder.

St. Hurmius, in the *German Ephemerides*, says, that in the northern countries, flames often burst from the stomachs of persons in a state of intoxication.—Three noblemen of Courland having laid a bet which of them would drink the most spirits, two of them died in consequence of suffocation by the flames, which issued in great violence from their stomachs.

On the night of the 16th of March, 1802, in one of the towns of the State of Massachussetts, the body of an elderly woman disappeared from some internal cause, in the duration of about one hour and a half. Part of the family had gone to bed, and the rest were abroad. Shortly after, one of the grandchildren came home, and discovered the floor near the hearth to be on fire. An alarm was made; a light brought—and means used to extinguish it.—While these things were being done, some singular circumstances were observed on the hearth and the contiguous floor. There was a sort of greasy soot and ashes, with remains of a human body, and an unusual smell about the room. All the clothes were consumed, and the grandmother was missing. It was at first supposed she had, in attempting to light her pipe, fallen into the fire and been burned to death; but every thing confirmed the idea of spontaneous combustion.

The spontaneous combustion of *vegetable substances* is a matter of no less interest to the judicious inquirer, than that of animal bodies. This too is peculiar, because it is a deviation from the ordinary course of nature, and there can be no doubt but it often occurs, giving rise to many of those conflagrations for the origin of which no adequate cause can be assigned, but where a suspicion of other causes is very often implicated. When spontaneous combustion occurs in vegetable substance, in every instance either phosphorus or one of its combinations, or a vegetable essential oil, with some light fibrous matter is present. Chemists have, however, but barely noticed the subject. Dr. Henry states, that the expressed oils possess the remarkable property of inflaming any light vegetable matter or carbon with which they may come in contact. Hay, charcoal, dunghills, and pigeons' dung, with many other substances, have long been reputed to be liable to spontaneous combustion.

Perhaps the most remarkable cases of spontaneous combustion, are those in which it has arisen in clothes, saturated probably with a peculiar animal matter emitted in perspiration. John de Viano, in a treatise *De Peste Malagensis*, p. 46, relates, that the wife of

Dr. Freilas, physician to the Cardinal de Royas, Archbishop of Toledo, sent forth naturally by perspiration, a fiery matter, that if the roller that she had worn round her body was taken from her and exposed to the atmosphere, it was immediately kindled, and shot forth like grains of gunpowder. And Peter Borelli says, "there was a certain peasant, whose linen, hempen thread, &c., if laid up in boxes, though wet through, or hung upon sticks in the air, did soon take fire."

Charcoal has frequently been known to ignite spontaneously. Two instances of this kind of combustion took place in the powder-manufactory of Essones, in the years 1708 and 1709. The first time, the fire broke out in the box employed for sifting the charcoal; and the second time, the charcoal repository took fire: on each occasion there were no data to which to ascribe the accidents, but to spontaneous inflammation. The reports of these two events, with the opinions of the French philosophers, were inserted in the public journals of the day. Three successive explosions likewise took place in the mills of Vonges; these were attributed to the same cause.—It appears very probable that in these cases, the immediate cause of the combustion is the phosphorus contained in charcoal; this explanation is the more founded on reason, because the alder wood used at Essones, as well as in most continental gunpowder manufactories (and on which account it maintains a preference over other woods for making gunpowder), contains much phosphoric acid.

Instances have been known in which houses have been set on fire, by ashes intermingled with charcoal, being taken too hot from the hearth, and which having been deposited in places where they were surrounded with combustibles, have occasioned inflammation. Happily this cause of fire rarely occurs; but care should be taken not to put ashes which are newly burnt, and which are still mixed with charcoal, in places where they may have a communication with combustibles.

There are many vegetable substances, which by torrefaction acquire an increase of property to ignite spontaneously, particularly in situations where they are exposed to the action of the atmosphere. Of this kind are saw-dust, burnt coffee, the farina of gramineous, and the fruits of leguminous plants, such as beans, peas, lentils, &c.

The following singular case of spontaneous combustion is described by Mr. James Gullonan, of Glasgow, in the seventh volume of the *Edinburgh Philosophical Journal.* "Having sold a respectable dealer a parcel of sample bottles, I sent them to him in an old basket, the bottom of which was much broken.—To prevent the bottles from falling through, I put across the bottom of the basket a piece of old packing sheet, which had lain long about an oil and colour warehouse, and was besmeared with different kinds of vegetable oil. About six or eight weeks after, the gentleman informed me, that my oily cloth and basket had almost set his warehouse on fire. The basket and cloth had been thrown behind some spirit casks pretty much confined from the air, and about mid-day he was alarmed with the smell of fire.—Having moved away the cases in the direction where the smoke issued, he saw the basket and cloth in a blaze.

The eighty-fourth volume of the *Philosophical Transactions* contains the following case, which happened at Bombay. On going into the arsenal (observes the writer, Isaac Humphries, Esq.), I found my friend Mr. Goulding, the commissary of stores, in the greatest uneasiness in consequence of an accident which had happened the preceding night. A bottle of linseed oil had been left on a table, close to which stood a chest containing some coarse cotton cloth. In the course of the night the bottle of oil had been thrown down and broken on the chest (by rats most probably), and part of the oil ran into the chest, and on the cloth; when the chest was opened in the morning, the cloth was found in a very strong degree of heat. and partly reduced to tinder, and the wood of the box was also discoloured, as by burning. After a most minute examination, no appearance of any other inflammable substance could be found, and how the cloth could have been reduced to the condition in which it was found, no one could conjecture. The idea which occurred to, and made Mr. Goulding so uneasy was, that of an attempt to burn the arsenal. Thus matters were when I joined him, and when he told me the story, and showed me the remainder of the cloth. It luckily happened that, in the course of some chemical amusements, I had occasion to consult *Hopson's Chemistry* a few days before, and there I met with a particular passage on spontaneous combustion, which fully explained the fact to which my friend had adverted.

One of the most singular well-accredited cases of spontaneous combustion that we recollect to have seen, is described in the *American Journal of Science* for 1832. The author thus describes the phenomenon:—"We have, in our family room, adjoining the kitchen, a Philadelphia cooking-stove, in which, when the weather is cold and the price of fuel is high, some little culinary processes are at times carried on. For this winter the floor has been covered with some cheap domestic carpeting. The stove stands on the carpet, which being tacked down, and covered in places with oil-cloths, has not been taken up during the winter. Of course, some grease spots had appeared contiguous to a side door of the stove, but they had been scoured off so as hardly to be discernable on the upper surface.

"Some weeks ago, about noon, I was writing in this apartment, and having in charge two little children, the oldest one then called my attention to the smoke which then filled the room. My first impression was, that the house was on fire, probably in the kitchen; but on opening the door, first of that room, and then of the parlour, no smoke was perceived in either, and I closed those doors, and began to search more narrowly. On looking at the carpet, I could see the smoke rising through it everywhere. I then looked into the cellar, found no smoke there, and closed the door, to prevent too free an ingress of air, and the bursting into flame. The carpet was then carefully examined by the eye and hand, and one spot was found, and only one, where there was heat enough to make smoke. That spot was on one side of the stove, more than two feet distant from it, and the carpet was whole, though warmed, but not hot, for I could bear my hand upon it. I applied some snow to it, and found a browned spot of about two inches in diameter, which soon became a hole of that size, corresponding with one in the white pine floor-plank underneath, which was browned and charred, not burned, less than half-way through the plank. This occurred in a seam of the floor, where the

planks were joined, and in what had been one of the spots of grease: whether in contact with a nail, I have not yet ascertained. This is clearly an alarming case of *incipient spontaneous combustion.* The carpet, the materials of which had, till now, escaped observation, was found to be made of cotton and flax tow, with streaks of woollen yarn filling, none of which, however, came within the charred hole above described. In the hope to guard others against similar dangers, these facts are communicated."

We stated at the outset of this article that we had little more than *facts* to communicate. In the present state of our knowledge on the subject, it would be improper to theorise. There is, however, one important lesson to be derived from a perusal of these accredited cases of spontaneous combustion,—namely, to weigh well the evidence which is adduced in cases of incendiarism, and pause ere we condemn an accused person to an ignominious death, when the mischief of which the individual is accused may have originated in accidental circumstances.

COME SOPRA, in *music*, an allusion to the manner of performing some former passage, the style of which performance has been already denoted.

COME STA, in *music*, an expression implying that the performer is not to embellish the passage with any additions of his own.

COMETS. See ASTRONOMY and ECLIPSE.

COMMENSURABLE; among geometricians, an appellation given to such quantites or magnitudes as can be measured by one and the same common measure.

Commensurable numbers, whether integers or fractions, are such as can be measured or divided by some other number, without any remainder: such are 12 and 18, as being measured by 6 or 3.

COMMERCE OF THE WORLD. This embraces the whole subject of the traffic and intercourse of nations, and shows how mutual wants, occasioning the exchange of natural riches for the creations of art, unite savage nations with civilized, and spreads moral and social cultivation over the earth. In former times, commerce subdued the *steppes* of Scythia and the deserts of Libya, and it is now clearing away the primitive forests of America, and draining the waters of Australia. For thousands of years, it has pervaded the interior of the ancient world; for centuries it has had its path on the mighty ocean; and of late it has studied how to cut through the isthmus of Darien, and to break through the ice of the poles. In the history of nations, it is a perpetual Argonautic expedition, and, from the first period of commerce down to our own times, its Colchis has been India. The limits of our work do not allow us to exhibit the progress of commerce in ancient times, and we shall merely give a cursory survey of the principal commercial nations of the present period.

I. EUROPE, since the conquest of Tyre by Alexander, has been in the possession of the commerce of the world, and has secured it by its colonial system, by means of which it exercises the monopoly of colonial commodities. By this we understand the productions of the planting, commercial, and mining colonies; those of the last, however, only in part, for the precious metals and stones can hardly be designated by that name. This is also true of the productions of the colonies more strictly agricultural: spices, East India goods of all kinds, dye-woods and cabinet-woods, drugs, cotton, and especially coffee, sugar, rice, tea, &c., are properly understood by this term. The East Indies furnish chiefly cotton, sugar, coffee, rice, fabrics of various kinds, spices, and tea (from China); the West Indies, cocoa, coffee, sugar, and cotton; South America, the precious stones and metals, dye-woods, cabinet-woods, drugs, &c. The consumption of these articles, which was formerly possible only for the rich, has increased immensely since the ocean became the highway for trade with the East Indies and America, in the course of the 15th century, and more especially since the English and Dutch assumed the first station among the colonial nations of Europe, in the beginning of the 18th century. Instead of being, as before, mere objects of luxury for the higher ranks, colonial goods became necessary articles even for the lowest classes of Europe; and an entire revolution was produced in the civil and political condition of that portion of the world. Commerce thus acquired an incomparably higher importance, and a more general interest. The class of merchants, which was by this means increased in an extraordinary degree, soon formed a body of men, spread over the whole cultivated world, and animated by one purpose—to maintain commerce; and even among belligerent nations, governments have endeavoured in vain utterly to abolish the mutual dealings of merchants. Thus, as the intercourse of nations became more lively, the exchange of ideas was promoted, men's views became enlarged, a cosmopolitan spirit united distant communities, and formed of the nations of Europe, as it were, one great, civilized family. Equal results were produced by the increased importance of the colonial powers (in late times, the two maritime states of England and Holland, in particular), arising from the increasing consumption of colonial goods. For them, and, indeed, though in an inferior degree, for the other colonial powers of Europe, the trade in the productions of the colonies was an important source of wealth and power. Their great political importance has exercised an extensive influence on the whole political condition of Europe. England in particular, has become continually more powerful by its extensive trade. It was therefore in the natural course of things, that, when the immense power of France was developed by the revolution, and that country, under Napoleon, strove for predominance on the European continent, the greatest struggle should take place between France and England, a consequence of which was the continental system of Napoleon, who declared his purposes to be, to free Europe from the tribute which it was obliged to pay to England for the colonial goods which it received from her. England, deeming it absolutely essential to her interests to prevent the establishment of an universal monarchy on the continent, spared no exertion to procure the restoration of the former order of things, so that she might have a free intercourse with the continental ports. Without going into the points at issue between Great Britain and France, the fact deserves to be stated, that the continental system called into action many kinds of industry on the continent, and, in this way, has produced important changes in the course of trade, resulting from the great increase of manufactures. If we examine whether it be actually true, as asserted in the time of the continental system, that the great use of colonial goods must necessarily produce poverty, it is easy to prove the contrary, which has been already fully con-

formed by experience. New wants gave rise to new energy and new branches of industry, in order to gratify those wants, thus increasing the productiveness of labour, and, simultaneously, the prosperity of every nation. But it is objected that money, or the produce of labour, which would otherwise remain in the various countries, is sent away from them in exchange for colonial goods. Very true; but, even if the express purpose of acquisition were not to procure new enjoyments, the object of all trade and all activity is, not to accumulate money, but to augment the sum of happiness. If this object be attained, industry and trade have effected all that they should do. Of course, no account can be reasonably taken of the small number of idle spendthrifts, who, without labouring, consume their capital in gratifying their pleasures. But it was soon perceived, that, in the existing state of Europe, entirely to exclude colonial articles was utterly impossible, though recourse was had to all kinds of substitutes. The enormous duties imposed on the importation of colonial goods, as far as the French power then reached, that is, throughout nearly all the continent of Europe, contributed essentially to render its nations poorer; for these duties had to be paid, while nothing of value could be given in return, from which circumstance originated a most pernicious and immoral smuggling trade. But Napoleon asserted that the English would not allow him to make peace, in which case the whole system would naturally have been changed.

In the 18th century, *Great Britain* became the first colonial power. It, therefore, stands at the head of the commercial nations, who are all, more or less, tributary to British art and industry. Its commerce is, in a great measure, managed by companies.

The chief exports of Great Britain are, to the north of Europe, cotton and woollen cloth, glass, hardware, pottery, lead, tin, coal, East India and colonial wares, dye-stuffs, salt, and refined sugar. In return, Great Britain receives from the north, corn, flax, hemp, iron, turpentine, tar, tallow, timber, linen, pearl and pot-ashes, cordage and hog's bristles. To Germany, Holland, France, Italy, Spain, and Portugal, it exports cotton and woollen fabrics, cutlery, dried and salt fish, pottery and glass-ware, colonial and East India goods, and all kinds of the finer manufactures. From Germany it imports corn, flax, hemp, linen cloth and thread, rags, hides, timber, and wine. From Holland, flax, hemp, madder, gin, cheese, butter, rags, and seeds. From France, wine, brandy, lace, cambric, silk ornaments, and fancy goods and fruit. From Italy, Spain, and Portugal, silk, wool, barilla, sulphur, salt, oil, fruit, wine, brandy, and cork. To Turkey it sends cotton and woollen goods, hardware, colonial and East India goods, lead, tin, iron, clocks, and watches; receiving, in return, coffee, silk, fruits, fine oil, dye-stuffs, carpets, &c. To North America it sends woollen and cotton manufactures, hardware, linen, glass, and other wares: the imports from thence are flour, cotton, rice, tar, pitch, pot and pearl-ashes, provisions, ship-timber, &c. The chief imports from South America are cotton, hides, skins, tallow, cochineal, dye-wood, sugar, indigo, cocoa, gums, &c.; and the exports from England are the same as above mentioned. The same exports are likewise sent to the West Indies; and, in return, Great Britain receives rum, coffee, tobacco, sugar, ginger, pimento, pepper, indigo, dye-stuffs, drugs, gums, cotton, mahogany, Campeachy wood, &c. To the East Indies, China, and Persia, it sends woollen goods, iron, copper, lead, tin, foreign silver money, gold and silver in bars, hardware, and a variety of manufactures; for which it obtains muslins, calicoes, silks, nankeens, tea, spices, arack, sugar, coffee, rice, saltpetre, indigo, opium, drugs, gums, quicksilver, precious stones, pearls, &c. To the colony of New South Wales, the common English manufactures and colonial goods are exported, and exchanged for train-oil, seal-skins, wool, &c.

Internally, Great Britain trades in the following commodities. From Scotland, England and Ireland receive corn, cattle, woollen and cotton goods, pot-ash, coals, canvass, and iron manufactures; the Scottish fisheries also furnish an important article of commerce. For these things, Scotland receives the productions of Ireland, and articles of luxury, of all kinds, from England. Ireland buys of England and Scotland, woollen, cotton and silk goods, East and West India goods, pottery, hardware, and salt; and, in exchange, gives its linen, hides, potatoes, and other provisions, &c. The foreign commerce of Ireland is, besides, very extensive. It exports its productions and manufactures to France, Spain, Portugal, the West Indies, and North America, for wine, fruit, sugar, rum, &c. The commercial intercourse between Ireland and the north of Europe is mainly through England, and its trade with the East passes exclusively through the same channel. The chief articles of export from Ireland are linen, potatoes and other provisions, corn, whiskey, herrings, and salmon.

The foreign possessions, settlements, and colonies of Great Britain, of which it possessed 26 prior to the French revolution, and has gained 17 more by conquest, are Heligoland, Gibraltar, and Malta, with Gozo and the Ionian Isles, in Europe; its possessions in India, under the administration of the East India Company, and Ceylon, in Asia; the Isle de France, or Mauritius, with the Sechelles and Amirante Isles, the Cape of Good Hope, Sierra Leone, Cape Coast and Annaboa, the islands of Ascension and St. Helena, in Africa; Canada, New Brunswick, Nova Scotia, Cape Breton, St. John's, or Prince Edward's Island, Newfoundland, Hudson's Bay, and the bay of Honduras, in North America; Berbice, Essequibo, and Demerara, in South America; Jamaica, Barbadoes, Antigua, St. Vincent, St. Christopher, Nevis, Montserrat, the Virgin Islands, Grenada, Tobago, Dominica, Trinidad, and the Bahamas, in the West Indies; also the Bermudas; in Australia, New South Wales, Van Diemen's Land, and the colony of New Zealand, and Melville's Island.

The most important commercial cities of England, besides London, are Liverpool, Bristol, and Hull; the most important manufacturing towns are, Manchester, Birmingham, Leeds, Nottingham, Halifax, Rochdale, &c. In Scotland, the principal commercial places are Glasgow, Greenock, Leith, and Aberdeen. The foreign trade of Glasgow and Greenock extends to the West Indies, the United States, the British American colonies, Brazil, and the whole continent of Europe. The foreign trade of Leith and Aberdeen extends to the West Indies, America, the Mediterranean, and the Baltic. The greatest commercial cities of Ireland are, Dublin, Cork, Wexford, Waterford, and Belfast.

TABLE I.

An Account of the Official and Declared Value of the Imports to and Exports from the United Kingdom, from and to each of the British Colonies and Possessions, for the Year ending 5th January, 1831; *being the last account laid before the House of Commons; distinguishing British and Colonial and Foreign Produce.*

Names of the British Colonies, &c.	Official Value of Imports into the United Kingdom.			Official Value of Exports from the United Kingdom.						Declared Value of British and Irish Produce and Manufactures exported from the United Kingdom.		
				British and Irish Produce and Manufactures.			Foreign and Colonial Merchandize.					
EUROPE:	£.	s.	d.	£.	s.	d.	£.	s.	d.	£.	s.	d.
Heligoland	98	17	11	122	15	8	152	12	8	78	5	5
Gibraltar	24,186	3	8	547,465	14	1	127,360	17	5	292,760	1	4
Malta	42,462	12	5	340,920	14	1	49,622	18	6	189,135	3	10
United States of the Ionian Islands	100,570	9	9	72,817	11	1	21,075	16	11	56,962	15	4
Isles of Guernsey, Jersey, Alderney, and Man	257,783	8	2	399,184	3	5	108,552	16	7	344,035	12	11
AFRICA:												
Sierra Leone & Settlements on the Western Coast	312,610	16	5	368,566	0	10	133,770	17	10	252,123	6	2
Cape of Good Hope	171,572	5	9	476,500	2	9	78,752	16	9	330,035	13	8
St. Helena	57,570	9	6	26,045	0	7	2,341	2	9	38,915	2	0
Mauritius	675,345	3	5	228,279	19	4	19,408	3	4	161,028	11	2
ASIA:												
E. I. Company's Territories, Ceylon, &c. (including China), the trade with which country cannot be separately distinguished	7,555,632	16	11	6,644,132	3	6	438,706	0	8	3,905,997	9	6
New South Wales	68,276	6	8	213,230	4	11	49,602	13	7	206,204	12	5
Van Diemen's Land	49,282	11	3	89,651	9	6	12,239	12	3	94,429	16	11
Swan River	......			12,794	16	7	4,119	4	6	14,042	0	3
AMERICA:												
British Northern Colonies; *viz.*												
Settlements of the Hudson's Bay Company	32,857	3	3	81,899	10	7	8,244	8	1	91,136	2	3
Newfoundland and the coast of Labrador	264,031	16	6	278,352	14	0	48,392	7	9	294,249	17	9
Canada	682,202	6	9	1,388,201	9	5	181,818	18	3	997,501	19	2
New Brunswick	220,094	6	6	245,898	12	9	30,592	7	10	215,448	6	2
Nova Scotia, Cape Breton, and Prince Edward's Island	66,664	6	4	321,413	6	7	34,749	9	8	258,796	12	4
British West Indies; *viz.*												
Antigua	267,654	11	11	106,091	3	8	8,198	18	7	92,316	9	8
Barbadoes	541,707	19	0	337,082	4	6	21,495	1	8	271,796	11	0
Dominica	149,322	0	1	13,816	9	4	2,085	1	7	14,147	10	8
Grenada	337,921	14	10	74,416	15	0	4,669	17	10	75,365	13	10
Jamaica	3,653,265	17	8	1,699,091	0	0	106,364	1	4	1,246,995	6	6
Montserrat	32,581	7	3	7,417	12	2	569	17	2	8,077	2	9
Nevis	80,333	14	10	13,947	17	1	335	12	8	16,068	13	5
St. Christopher	202,917	10	4	68,657	19	2	3,508	15	3	53,084	10	10
St. Lucia	148,394	0	11	28,344	19	7	3,715	6	3	21,305	2	5
St. Vincent's	394,912	18	10	79,863	17	3	3,052	16	0	77,370	8	1
Tobago	164,735	14	4	38,074	5	8	3,266	0	9	41,131	14	5
Tortola	25,211	12	7	2,807	3	4	28	10	0	3,531	1	0
Trinidad	354,788	0	10	173,078	2	9	24,552	14	3	139,517	1	5
Bahamas	21,428	3	1	56,949	6	10	1,769	11	7	41,440	1	10
Bermudas	4,014	1	0	43,708	3	9	16,652	4	11	40,923	18	3
Demerara	1,627,060	19	6	419,363	8	11	31,878	3	5	426,316	3	8
Berbice	370,985	6	8	66,556	11	4	6,883	14	3	69,442	0	6
Honduras	221,855	1	3	520,531	10	1	51,851	9	11	199,618	7	4
British Whale Fisheries	195,591	6	0	—			2,108	2	0	—		
Total . . . £.	19,375,924	2	1	15,485,275	0	1	1,642,480	4	9	10,581,329	6	2

TABLE II.

An Account of the Amount of the Official and Declared Value of the Imports to and Exports from the United Kingdom, from and to all Foreign Countries, for the Year ending 5th *January,* 1831; *being the last account laid before the House of Commons; distinguishing each Country, and British and Colonial and Foreign Produce.*

Names of the Foreign Countries.	Official Value of Imports into the United Kingdom.			Official Value of Exports from the United Kingdom. British and Irish Produce and Manufactures.			Official Value of Exports from the United Kingdom. Foreign and Colonial Merchandize.			Declared Value of British and Irish Produce and Manufactures exported from the United Kingdom.		
EUROPE:	£.	s.	d.	£.	s.	d.	£.	s.	d.	£.	s.	d.
Russia	4,203,504	14	7	2,261,295	13	10	770,728	15	11	1,489,538	7	3
Sweden	156,747	2	4	60,666	17	0	94,190	6	8	40,487	18	4
Norway	74,930	4	10	99,277	15	2	35,104	15	5	63,925	13	6
Denmark	370,847	15	8	221,786	7	3	99,177	3	10	118,812	15	2
Prussia	1,595,801	0	10	219,184	17	11	416,065	18	3	177,922	19	9
Germany	2,010,539	7	1	8,641,693	5	1	1,566,380	12	4	4,463,527	4	4
The Netherlands	1,415,881	2	8	2,896,277	10	3	1,735,266	0	2	2,022,458	8	9
France	2,317,686	2	7	478,021	11	0	181,065	1	5	475,884	3	2
Portugal, Proper	445,394	17	9	2,088,361	3	4	38,024	4	1	1,106,694	16	10
——— Azores	16,337	19	6	40,804	19	4	2,188	5	2	23,620	6	2
——— Madeira	18,635	8	0	58,092	14	11	7,677	1	3	38,444	6	0
Spain and the Balearic Islands	1,115,534	13	8	976,907	17	3	146,550	19	8	607,067	11	9
Canaries	86,063	14	6	71,326	10	9	14,372	12	10	42,619	18	1
Italy and the Italian Islands	1,104,309	15	4	5,685,841	1	3	787,145	17	3	3,251,378	10	5
Turkey and Continental Greece	726,065	11	8	2,745,723	16	1	140,038	14	7	1,139,616	9	0
Morea and Greek Islands	9,236	4	6	28,274	6	2	598	10	0	9,694	0	0
AFRICA:												
Egypt	129,169	10	11	237,184	7	5	1,908	17	0	110,227	6	6
Tripoli, Barbary, & Morocco	40,767	11	0	1,648	3	10	493	19	0	1,138	6	11
Senegal	—			—			—			—		
Cape Verde Islands	—			2,513	3	11	418	10	3	1,710	6	0
Isle of Bourbon	30	12	0	9,733	18	1	—			10,041	10	0
ASIA:												
Ports of Siam	—			17,870	4	5	1,495	13	4	10,467	10	0
Sumatra, Java, and other Islands of the Indian Seas	86,026	9	1	257,680	13	8	4,329	8	7	151,634	2	8
Philippine Islands	58,589	19	9	172,817	6	5	1,350	5	7	71,219	15	4
New Zealand and South Sea Islands	5,299	10	8	1,298	6	6	223	13	4	1,396	3	3
AMERICA:												
Foreign West Indies; *viz.*												
Hayti	102,885	6	1	822,076	0	7	9,880	1	9	321,792	17	10
Cuba	287,440	8	3	550,229	18	11	6,155	3	7	371,669	17	11
Porto Rico	26,015	8	9	522	11	2	192	8	2	744	18	6
Guadaloupe	1	0	0	—			—			—		
St. Croix	7	14	5	1,878	2	9	—			1,558	11	0
St. Thomas	4,328	7	2	472,738	6	7	29,010	16	4	232,569	16	2
Cayenne	10,843	15	9	11,221	9	8	39	7	8	11,486	0	0
Surinam	898	19	5	—			—			—		
United States of America	8,055,962	7	1	7,843,907	4	11	392,769	16	2	6,132,345	15	3
States of Central & Southern America; *viz.*												
Mexico	169,222	18	7	1,574,410	14	1	320,406	13	0	978,440	11	0
Columbia	52,869	13	4	427,718	2	0	5,854	1	2	216,751	8	10
Brazil	1,530,557	19	5	4,270,748	18	1	45,457	19	7	2,452,103	3	11
States of the Rio de la Plata	583,946	12	7	1,067,884	1	0	12,679	11	1	632,171	15	8
Chili	25,074	17	10	835,566	0	8	23,094	6	6	540,626	1	11
Peru	85,254	14	10	513,894	14	11	15,569	13	2	368,469	6	11
Total . . . £.	26,923,709	12	5	45,667,078	16	2	6,905,905	4	1	27,690,267	14	1

The preceding tables exhibit a view of the gross amount of the commerce of this country, distinguishing the component portions of it carried on with each colony and foreign states for the year ending 5th January, 1831. The like accounts for the following year have not yet been printed by the House of Commons; we are enabled, therefore, to give only the gross amount of the commerce of the United Kingdom with foreign countries during that period.

Trade of Great Britain with Foreign Parts for the Year ending 5th January, 1832.

Exports:	Official value.	Real value.
British and Irish produce and manufactures . .	£. 60,090,123	£. 36,652,694
Colonial and foreign produce	10,729,943	—
Imports	48,161,661	—

Trade of Ireland with Foreign Parts for the Year ending 5th January, 1832.

Exports:	Official value.	Real value.
British and Irish produce and manufactures . .	£. 593,810	£. 510,953
Colonial and foreign produce	15,129	—
Imports	1,552,228	—

Germany. On account of its navigable rivers, the commerce of this country is considerable. The chief articles of export are linen, linen yarn, raw wool, rags, quicksilver, corn, timber, flax, hemp, wax, lard, salt, wine, and metals. Its imports are woollens, cottons and silks, hardware, watches, tanned leather, leather goods, tea, cocoa, dye-woods, hides, colonial and East India goods. The principal ports of Germany are Hamburg, Lubeck, Bremen, Trieste, and Dantzic. In the interior its chief commercial cities are Vienna, Magdeburg, Leipsic, Frankfort on the Maine, Frankfort on the Oder, Augsburg, Berlin, Breslau, Cologne, Nuremberg, Brunswick, Mentz, Botzen, and Prague. Hamburg, in particular, is the channel through which flows, for the most part, the extensive trade between Great Britain and the German states. By means of the rivers running into the Elbe, the navigation of which has now become free, the numerous and valuable productions of Upper and Lower Saxony, of Austria, and Bohemia, go to Hamburg. By the Havel, the Spree, and the Oder, its commercial operations are extended to Brandenburg, Silesia, Moravia, and Poland. The business of Hamburg consists, in part, of the consignments of foreign merchants, and, to a great extent, of the purchase and sale of domestic and foreign goods. Its money transactions are very considerable. Bremen has important articles of export in the products of Westphalia and Lower Saxony, which it sends to England, Spain, and Portugal; and with America it has more intercourse than any other seaport of Germany. The trade in linens, which foreign countries carry on with Germany, passes wholly through the hands of the Hamburg and Bremen merchants, to whom all foreign orders are directed. The importation of tobacco from America into Germany is almost wholly through Bremen. Leipsic, the centre of European trade with the interior of Germany, and the place of deposit for foreign and Saxon goods, has, besides other mercantile privileges, three fairs (Easter, Michaelmas, and the New Year), to which merchants resort from all parts of Europe, and from Asia, and each of which lasts three weeks: there is, besides, at this place, a considerable market for Saxon wool. The chief articles of traffic are Bohemian, Silesian, and Saxon linen; leather, hides, wax, and wool, from Poland; woollen goods and pigments, from Prussia; silks, velvets, and corals from Italy; leather, various manufactures, and dye-stuffs, from Austria and Hungary; laces, silk goods of all kinds, ribbons, porcelain, watches, bronze and other manufactures, including fancy articles, from France; leather, hemp, and flax, from Russia; colonial commodities and manufactures, from England and Holland; and literary productions from all Europe. There is, also, in Leipsic, an important horse-market. Augsburg, by means of its agents and bankers, is the medium of mercantile communication between Germany and the south of Europe. The exchange business of Vienna is commonly transacted by drafts on Augsburg. It also derives considerable advantage from the forwarding of goods to and from Italy. Frankfort on the Maine, a place of great commercial activity, especially at the time of its two great fairs, in the spring and autumn, has, besides, a very important business, owing to the opulence of its old and new banking-houses. It is the commercial centre for the Rothschilds. In Brunswick, considerable business is transacted in its natural productions and manufactured articles, as well as in foreign goods. Its two great yearly fairs rank immediately after those of Leipsic and Frankfort. Great quantities of raw thread are sent thither by the Dutch merchants, and the strong beer, called *mum*, is exported to various parts of the world.

Austria is entirely separated from Germany by its system of imposts and its commercial regulations. Its trade is mostly carried on by land, or on the rivers. Vienna, the store-house of the inland trade of all Austria, has a very extensive commerce with England, the Netherlands, and France, and important dealings with Italy, Hungary, Poland, and Turkey. By the way of Vienna, Germany receives great quantities of raw cotton from Turkey. The commerce of Trieste, in the Littorale, consists chiefly in the exportation of German productions and of colonial goods, which go from thence to the Levant and the coasts of the Black Sea. Trieste may be regarded as the depôt of the productions of the Levant. It is also actively engaged in the importation of British wares, and of the produce of the fisheries of Newfoundland. Except this city, the commerce of Austria is confined to Venice and Fiume. The most considerable places of inland trade in the monarchy, besides Vienna, are Lemberg, Prague, Brunn, Brody, Botzen, Pest, and Cronstadt. The allowed imports consist mainly of raw produce, cotton and wool, silk, rice, oil, spices, colonial articles, leather, cattle, &c. The articles of export are woollen cloths, linens, cordage, mineral productions, grain, and glass. Great profit is derived from the transportation of goods, especially of those of the Levant. In Bohemia, far the greater portion of the trade is in the hands of the Jews, who are numerous in the country. The trade is chiefly in exports: linens, woollens, silks, dye-wood, leather, and glass. The glass is superior in polish and cheapness to that of other countries, and the exportation of it is very considerable. It is thought that the goods exported to Spain, Russia, the Levant, and America, amount to 2,500,000 guilders annually. The countries with which Bo-

hemia has the most commercial intercourse are Austria, Holland, Spain, Portugal, Italy, and Turkey. The exports are rated at from 5,000,000 to 6,000,000 dollars, and the imports (colonial goods, articles of luxury, &c.) at from 4,000,000 to 5,000,000 dollars. Prague is the first commercial city of the country; Reichenberg the second.

Prussia has likewise, by its system of prohibition, been separated from Germany with respect to free commercial intercourse, especially since 1818. The commerce of this monarchy is promoted by the Baltic, by many navigable rivers, and by canals. The commerce in domestic productions is more important than the transportation and commission trade, which flourishes mainly in Cologne, Magdeburg, Stettin, Minden, Dantzic, Königsberg, Breslau, &c. The exports by sea are grain, wax, tallow, wool, linseed, flax, hemp, wood, linen, yarn, woollen and cotton goods, fine works of art, including articles made of amber. Of the different commercial places, Frankfort on the Oder has three considerable fairs. Magdeburg sends corn, linen, cotton goods, cloths, leather, salt, and copper, to Hamburg, and to the fairs of Leipsic and Brunswick. It has, besides, a transit trade in colonial goods, wine, grain, &c. Wheat is exported from Dantzic, which possesses the largest granary in Europe; from Elbingen, Stettin, Königsberg, Anclam, and Berlin, timber; staves and ashes from Dantzic, Memel, and Stettin; hemp, flax and linseed, tallow, wax, and hog's bristles from Memel and Königsberg. Tilsit carries on a brisk trade in corn, linseed, hemp, and flax. The exports of Brunsberg are woollen yarn, corn, and flax. Colberg exports corn, and the other produce of Poland. The trade of Stralsund, likewise, consists chiefly in the exportation of corn. Of all the articles of Prussian commerce, the Silesian linen holds the first rank, and for the manufacturing of it, the Silesian towns Hirschberg, Landshut, Schmiedeberg, Friedland, Waldenburg, Schweidnitz, and the Prussian section of Upper Lusatia, are celebrated. This linen is particularly in demand among the Hamburg, English, Dutch, Italian, and South American merchants. The imports which have the readiest sale in Prussia are colonial goods, dye-wood, salt, Buenos Ayres hides, indigo, groceries, wine, silk, cotton goods, hardware, &c.

Hanover is not distinguished for its mercantile activity. The exports consist of horses, horned cattle, lead, wax, linen, leather, salt, oats, barley, timber, boards, and the ferruginous copper of the Hartz mountains. The linens are ordinary; the tablecloths and Osnabruck damask are inferior in quality to those of Prussia and Friesland. The surplus of the domestic consumption is exported to South America through the medium of the Hanseatic cities. The principal imports are English manufactures, especially woollen cloths and calicoes, colonial goods, Prussian and Friesland linen, fine French cloths, silks, jewellery, and French wines, with all kinds of small articles of luxury, which the Hanoverian merchant brings with him from the fairs of Brunswick, Leipsic, and Frankfort on the Maine. The chief commercial towns are Emden, Hanover, and Münden.

Denmark and Holstein. Although the Danish merchants have formed connections with all the commercial states of Europe, and play an important part in the commerce both of the Mediterranean and the Baltic, their own country possesses but few productions important as articles of export. Most of what they export are the productions of their East and West India possessions. To the ports of Petersburg, Riga, Stockholm, and Memel, Denmark carries the woollen goods of Iceland and the Faroe Islands; salt from Spain, France, and Portugal; and the productions of the East and West Indies and of China. To Germany it sends its horses, its cattle, colonial and West India goods, and woollen stockings, receiving in return linen, wool, brandy, and wine. To Holland it exports rape-seed, fish, &c., in exchange for groceries. To France, Spain, and Portugal it carries horses, fish, and other articles from Russia, in exchange for salt, wine, fruits, sweet-oil, brandy, silk, &c. Its trade with England consists, mainly, in exchanging timber, &c. for English manufactures. To Iceland it exports rye-meal, rye, barley, brandy, and other spirituous liquors, together with the common articles of consumption; receiving in return fresh, dry, and salt fish, train-oil, tallow, eider down, wool and woollen stockings. It supplies Greenland with flour, spirituous liquors, &c., in return for train and seal oil, seal-skins, eider down, and peltry.

The largest commercial towns of Denmark are Copenhagen and Elsinore in Zealand, Aalborg in Jutland, Flensborg and Tonningen in Sleswic, Altona and Kiel in Holstein. The West India colonies of Denmark are St. Croix, St. Thomas, and St. John's. On the coast of Coromandel, it possesses Tranquebar; on the coast of Guinea, Christianborg and other small places. It has also small factories on the Nicobar islands. In Europe it possesses Iceland. The chief commercial companies in Denmark are, the Asiatic or East India Company, the Iceland Company, the Maritime Insurance Company, the African or Danish West India, and the General Commercial Society.

France. The commerce of France extends to every country of the world. The exports are wine, brandy, oil, corn, meal, liqueurs, snuff, silks, woollens, fancy goods of all kinds, watches, porcelain, crystals, carpets, bronze, linen, lace, cambric, tapestry, hemp, flax, fruits, capers, salt, jewellery, paper, &c.; and France receives the raw produce of all countries, but very few manufactured goods. In 1824, the value of all the exports of France was 440,542,000 francs, of which 163,056,000 were in natural products, and 277,486,000 in manufactured goods. In the same year goods were imported into France to the amount of 189,535,000 francs in 3,387 French vessels, to the amount of 108,397,000 francs in 4,183 foreign vessels, and to the amount of 156,929,000 by land; the whole importation amounted to 454,861,000 francs. The principal ports are Bordeaux, Marseilles, Nantes, Havre de Grace, St. Malo, L'Orient, and Dunkirk. The commerce of Marseilles is mostly with the Levant and the West Indies; that of Bordeaux with Asia, the West Indies, and the north of Europe. Calais and Dunkirk carry on a very lucrative contraband trade with England. Havre de Grace is the seaport of Paris, which has a very extensive indirect trade, and dealings in bills of exchange with foreign countries. Amiens exports great quantities of velvet; Abbeville, Elbeuf, Louvier, and Sedan trade mainly in cloths; Cambray, Valenciennes, and Alençon, in cambrics and fine laces. Cette, the port of Montpellier, has an extensive trade in Spanish and colonial goods. The commerce of Bayonne is chiefly with

Spain. Silks form a principal article of the commerce of Lyons, which is situated in the centre of the roads leading to Switzerland, Spain, Italy, and Germany, and has annually four fairs. For Strasburg, its excellent turpentine is an important article of trade. Lisle has a direct intercourse, not only with all the commercial states of Europe, but also with the French and Spanish colonies, and with the Levant. The other commercial towns of importance are Rheims, Troyes, Grenoble, Nismes, Angouleme, Cognac, Nantes, Rouen, Rochelle, and Caen. Grenoble supplies France, Italy, Spain, and even Great Britain with fine gloves. Beaucaire has an important fair. The French colonies are Martinique, Guadaloupe, St. Lucia, and Mariegalante, in the West Indies; Cayenne, in South America, Pondicherry, Chandernagore, and some other possessions in the East Indies, with several factories on the western coast of Africa, and on both sides of Cape Verde.

Italy. Although Italy possesses the most excellent harbours on the Mediterranean and Adriatic seas, and has a geographical situation uncommonly favourable for commerce, its trade, both domestic and foreign, is very limited. The cause is to be sought in the impolitic restrictions, heavy taxes and imposts, to which the commercial cities are subjected in this most fruitful, but, for the most part, badly governed country. The chief articles of export from Italy are corn, olive-oil, wine, brandy, silk, cotton, wool, hemp, flax, velvet, damask, barilla (soda), sulphur, sumach, gall-nuts, madder, velani or velonia, and other dye-stuffs, senna leaves, liquorice juice and root, juniper berries and other drugs, anchovies, almonds, figs, nuts, olives, currants, raisins and other fruits, rags, chip and straw hats, the skins of sheep and kids, and marble. The principal commercial cities are Florence, Genoa, Leghorn, Naples, Venice, and Ancona. Leghorn is the main channel of the trade of Italy with the Levant and the Barbary states, and the central point of the commerce of England in the Mediterranean. A great part of its trade is in the hands of the Jews. Silks, taffeta, satins, brocades, light woollen goods, velvets, &c., are the main articles of export from Florence.—These pass through Leghorn, and sell readily in the Levant. Milan and Turin carry on a very extensive trade in their silk, which is celebrated throughout Europe for its admirable fineness and lightness.—Ancona has intercourse with the first commercial cities of Europe. Its business is chiefly agency and commission business. Some silk is exported from Nice. The exports of Lucca are olive-oil, silk, damasks, fruit, &c. Much olive-oil is exported from Gallipoli. The trade of Genoa continues considerable. Its exports are velvet, damask (which, next to the Venetian, is the most esteemed in Europe), raw silk, fruit, olive-oil, alum, marble, corals, coarse paper, &c. Venice, once the greatest mart of the world, notwithstanding the disappearance of its ancient splendour, is still an important place for commerce, a great part of the trade of Europe with the Levant being yet in its hands. The Venetian velvets, damasks, mirrors, and manufactured silks, in great quantities, form the most considerable constituents of the foreign trade of Venice. The exports of Naples are olive-oil, wool, silk, tartar, wines, raw and manufactured silk, fruit, sulphur, and staves.

The Islands of the Mediterranean Sea. The exports of Sicily, a country on which nature, with profuse generosity, has lavished in abundance all her gifts (the benefit of which, however, is almost destroyed by the weakness of the government), consist of silk, grain, barilla, sulphur, olive-oil, wine, cantharides, sumach, manna, coral, rags, almonds, figs, raisins, nuts, anchovies, amber, goat, buck, and sheep-skins, pomegranates, oranges, lemons, &c., and pine apples of remarkable size and exquisite flavour. The chief port is Messina; next to this comes Palermo.

The exports of Sardinia are, chiefly, grain of uncommon excellence, tunny-fish, hides, barilla, and salt. Cagliari is the most considerable commercial city.

Corsica exports silk, olive-oil, and black, white, and red corals. The silk goes mostly to Genoa and Lyons, and the corals are sold at Marseilles, where they are manufactured and polished, to be sent to Africa, to be sold to the Moors and Negroes. The Corsican ports are Ajaccio, Bastia, and Porto Vecchio.

Malta, which is, like Gibraltar, a depôt for British and colonial goods that are to be disposed of in the Mediterranean, exports cotton, oranges, and other fruits.

The Ionian islands (Cephalonia, Zante, Corfu, Santa Maura, &c.) export wine, brandy, olive-oil, raisins, currants, citrons, melons, pomegranates, honey, cotton, and salt. The raisins and currants are superior to those of the Morea in quality. The wine is Muscadel.

The commerce of the island of Cyprus is inconsiderable. It exports cotton, wool, silk, wine, salt, turpentine, Turkish leather, &c. Its largest commercial cities are Larnica and Rhodes.

The exports of the island of Candia, which, by its situation, is designed for the mart of the European, Asiatic, and African trade, consist of oil, soap, wax, wine, linseed, raisins, almonds, laudanum, St. John's bread (the fruit of the *ceratonia siliqua*), &c.

The Kingdoms of the Netherlands and Holland.—The chief commercial cities of the Belgic Netherlands are Antwerp, Ghent, and Ostend. Antwerp was formerly the mart of the commerce of the North of Europe. The exports of Antwerp consist, principally, of wheat, beans, clover-seed, linen, laces, carpets, tapestry, and all the manufactures of Brussels, Mechlin, Ghent, and Bruges. The articles of export from Ghent are wheat, fine linen, flax, hemp, beans, &c.; those from Ostend are wheat, clover-seed, flax, tallow, hides, and the linen of Ghent and Bruges.

The chief exports of Holland, the commerce of which has revived since 1814, and employs every year a vast number of vessels of various descriptions, are butter, cheese, linen, cloth, drugs and paints, fish, wheat, linseed, clover-seed, geneva (gin), dye-stuffs, paper, &c. The principal commercial cities in Holland are Amsterdam, Rotterdam, and Groningen. Before the decline of Dutch commerce, Amsterdam was one of the greatest commercial cities of the world, the mart of goods from the East and the West, and from the principal states of Europe. At the time when the Dutch were in exclusive possession of the spiceries of the East, of the silks of the East Indies and China, and of the fine East India cotton goods, they dressed in coarse cloth, and were satisfied with a very frugal mode of living. The fine cloths which they themselves manufactured, they destined wholly for foreign countries, and, for their own use, purchased coarse cloth in England. At that time, they likewise sold the superior butter and cheese which they made, and, for their own use, bought the cheaper sorts from

England and Ireland. To the exchange and banking business, of which the channel was Amsterdam, the Dutch were also, in part, indebted for their great prosperity. With Hamburg, Amsterdam is yet the centre of the exchange business between the North and the South of Europe, although, from the time that the credit of the bank of Amsterdam diminished, this branch of business has declined, a great portion of it being transferred to Hamburg and London.—The imports are grain, wood, coal, tallow, wax, rags, &c. For the colonial trade of Holland, the possession of Batavia, Amboyna, Banda, Ternate, and Macassar, in the East Indies, is of importance, as are also the commercial settlements on the Coromandel and Malabar coasts, and those at Bantam, Padang, Japan, &c. In Africa, Holland has some forts in Guinea; in America she possesses Surinam, and the West India islands of Curaçao, St. Eustatia, and St. Martin.

Poland. The exports of Poland consist of corn, hemp, flax, lumber, linseed, tallow, and salt. Its commerce is inconsiderable, and is almost wholly in the hands of the Jews. Warsaw and Cracow are the two largest commercial cities. The former has two fairs every year. Cracow has a situation very favourable to commerce, but the principal article of its trade is furnished by the celebrated salt-mines of Wieliczka, situated in the neighbourhood. At the fairs of Leipsic and Frankfort on the Oder, Poland is supplied with manufactures, and all articles of luxury, in exchange for hare skins and other productions.

Portugal. The Portuguese exports are, chiefly, white and red Port wine, Lisbon and Calcavella wine, salt, oranges, lemons, and other fruit, cork, silk, wool, sweet-oil, &c. To this country are sent Port wine, Lisbon, Calcavella, Madeira, and Canary wines, salt, oranges, lemons, cork, &c.; in return for which the Portuguese obtain British manufactures and colonial goods, provisions, corn, meal, copper, lead, coal, &c. Their exports to the North of Europe are wine, salt, fruit, &c.; for which they receive hemp, flax, corn, iron, timber, tar, pitch, stock-fish, and Russian and German linen. The chief commercial cities are Lisbon, Oporto, and Setubal, commonly called St. Ubes. The foreign possessions of Portugal are, the cities of Goa and Dieu in the East Indies, together with a part of Timor, the factory at Macao in China, the Azores, Madeira and Puerto Santo in the Atlantic, the Cape Verd islands, those of St. Thomas, Angola, and some settlements in Guinea and on the western coast of Africa, with Mozambique, Melinda, and other settlements on the eastern coast.

Russia. Russia exports, principally, iron, hemp, flax, cordage of all kinds, tallow, hides, fir and oak timber, boards, planks, laths, spars, pitch and tar, together with all kinds of grain, especially wheat, linen, canvass of various kinds, wax, honey, bristles, suet, soap, isinglass, caviare, leather, train-oil, hempseed, linseed, and tobacco. The chief commercial cities are Tobolsk, Irkutsk, and Tomsk, in Siberia; Astrachan, Orenburg, and Kasan, in Asiatic Russia; Moscow and Novgorod, in the interior of Russia; Archangel on the White Sea; Libau (though very much decayed) in Couriand; Taganrog, Caffa or Theodosia, Odessa, Cherson, Sebastopol, and Azoph, on the Black Sea and the Sea of Azoph; Riga, Pernau, Narva, Revel, Petersburg, Viborg, Fredericshamm, and Arensburg; the places where the fairs are held, are Niznie-Novgorod, Irbit, &c., connecting the caravan trade of the East with the inland trade of European Russia, which is promoted by canals and rivers. By the Black Sea and the Sea of Azoph, Russia carries on a very lively trade with various Turkish ports; on the Caspian Sea, with Persia; by way of Kiachta, with China; and, on the north-west coast of America, it is at present laying the foundation of its trade in the Pacific. Russia has lately sent an expedition from Kodiak northward, to make topographical surveys in the interior of North America, and to establish a commercial intercourse with the natives of this unexplored country. Her colonies in North America are well provided for. Her officers are gaining nautical knowledge in England, and numbers have been sent to the United States of America, where models of nautical architecture and vessels celebrated for sailing have been purchased on Russian account.

Sweden and Norway. The articles exported from the twenty-eight Swedish ports are iron, steel, copper, pitch, tar, fir, alum, and fish. The chief commercial cities are Stockholm, Gottenburg, and Gefle. Carlscrona carries on considerable trade in iron, timber, pitch, tar, tallow, potash, linseed, &c., which articles are sent mainly to the French, Spanish, and Italian ports, commonly in exchange for salt. The exports of Gottenburg are fish, iron, steel, and boards. The institutions of Sweden for the promotion of commerce are the Bank, the East India Company, the West India Company, the Levant Commercial Company, the Association of Industry, &c. From Norway are imported fish, oak and fir timber, deal boards, masts, alum, vitriol, fish and seal-oil, pitch, hides, woollen stockings, iron, copper, and tar. The chief commercial cities are Christiania, Bergen, Drontheim, Christiansand, Drammer, and Stavanger.

Switzerland. Switzerland has a considerable foreign trade. Its exports consist, chiefly, of fine linen, silks, velvets, imitations of East India goods, and shawls, fine calicoes, clocks, watches, ribbons, wine, cheese, honey, &c. The most important articles of importation are colonial and East India goods, from Holland; salt, grain, wool, and cloths, from Germany; raw cotton, silk, &c., from Italy; manufactures of various kinds, from England; wine and brandy from France. The principal commercial cities of Switzerland are Basle, Berne, Zurich, Geneva, and Neufchatel.

Spain. For three centuries, with the decrease of the industry of Spain, its trade has been on the decline. This country might have monopolized the commerce of the world, if it had understood and improved its situation. The natural wealth of the soil is, nevertheless, still the prop of its trade. The most important productions are wool, silk, salt, iron, copper, coal, quicksilver, barilla, rice, saltpetre, sugar, almonds, olives, oranges, lemons, figs, wines, brandy, and fruit. In Segovia and Leon, about 1,000,000 arobas of fine wool are annually collected, of which about four-fifths are disposed of to the French, Dutch, and English. The excellent Spanish wines, brandy, fruit, barilla, &c., are profitable articles for the country. From the port of Barcelona, excellent silks, coarse cloths and cotton goods, with wine, brandy, almonds, nuts, and other productions, are exported; in return for which, the same port receives the silks of Lyons, the hosiery of Nismes, various kinds of stuffs and cotton goods, German linen and dried stock-fish from England, amounting to

about 3,000,000 dollars. The exports of Valencia consist principally of silk, barilla (soda), coarse wool, dried fruits, wine, and brandy. The latter is exported chiefly by the Dutch, and carried to Normandy and Bretagne. The English carry to Spain, chiefly woollen cloth; the French, linen, woollen cloth, cutlery, groceries, &c. From the port of Alicant, the Spaniards export, chiefly dried fruits, silk, wool, barilla, wine, Castile soap, olives, saffron, a kind of cochineal called *grana*, and salt; of which last, the English and Swedes annually take upwards of 9,000,000 pounds. In Carthagena and Malaga, also, much business is done. From the latter, wines, dried fruit, almonds, sumach, anchovies, olive-oil, &c., are exported. Cadiz has been one of the principal marts in the world, both in ancient and modern times. In 1792, its exports to the two Indies amounted to the sum of 276,000,000 reals, and its imports to upwards of 700,000,000 reals (8 reals make 1 dollar). Madrid, the royal residence, is likewise an important commercial place and depôt. Seville carries on a considerable trade in oil and oranges, which are exported from Cadiz. Almost the whole Spanish coasting trade is in the hands of the French, Dutch, and English. The independence of Spanish America has almost annihilated the colonial power of Spain.

Turkey. The Turks are as yet very far from being a commercial nation, although their commerce with Austria, France, Italy, Great Britain, Holland, &c., by means of the Jews, Armenians, and Greeks living in Turkey, who have the trade of this country almost wholly in their hands, is by no means insignificant. The insurrection of the Greeks did, indeed, at first interrupt very much the commerce of Austria and other states; and the British were also formidable rivals on the Ionian isles; but Vienna, the centre of the Greek trade, has nevertheless retained its connection with Turkey, while the productions and the demands of the free Greeks must soon much increase. They offer cotton for linen, silk for cloths, gold for iron. Nature and habit recommend to them intercourse with Austria. On the other hand, the commerce with European Russia, by way of Constantinople to Odessa, was very much restricted by the Porte, subsequently to 1823, by the necessity of relading, to which it subjected the European vessels destined for Odessa, and by other burdensome regulations. This, however, has been changed by the peace concluded with Russia in 1829. Every vessel can at present pass the Dardanelles unmolested. This must soon have a great influence upon the Turkish trade also. In the Archipelago, the Greek struggle for freedom has given rise to many dangers to the commerce of neutrals. The chief commercial place is Constantinople, particularly in regard to the trade with Russia. Till within a short period, it distributed the Russian products through the ports of the Mediterranean. The exports of this city, which under a wise and active government, might become the true mart of the world, are of such little importance, that the great quantities of goods, imported for the use of Turkey, have to be paid for, almost wholly with gold and diamonds. In this port, the English, French, Italians, and Dutch, obtain the produce of Poland, the salt, the honey, the wax, the tobacco, and the butter of the Ukraine; the hides, the tallow, the hemp, the canvass, the peltry, and the metals of Russia and Siberia, and in exchange, give the productions of their own countries. This business is transacted without the Turks having the slightest part in it.

Hungary, is considered by Austria as a foreign country, and is encircled in by a line of custom-house officers. The trade of Hungary therefore is under different regulations from that of the rest of the empire, and is any thing but favoured by the government. Its foreign commerce is, nevertheless, by no means insignificant. The exports are wine, tobacco, gall-nuts, antimony, alum, potash, horned cattle, wool, iron, copper, wheat, rye, and barley. The exports by far exceed the imports. Goods can only be introduced through Austria and Turkey, the government having prohibited every other way that might be selected for the purpose.

II. Asia. The commerce of Asia is mostly inland, carried on chiefly, in Western and Middle Asia, by means of those caravans (called by a poet, the *fleets of the desert*), in which, sometimes more than 50,000 merchants and travellers are collected, while the number of camels is far greater. The central point of this trade by caravans is Mecca, which, during the presence of the caravans, offers to the eye of the traveller a more active trade and a greater accumulation of merchandize than any other city in the world. The muslins and other goods of the East Indies, the productions of China, all the spices of the East, the shawls of Cashmere, &c., are transported on the backs of camels to Mecca, from whence they are scattered over, not only the Asiatic, but also the African continent.

The *Arabs*, who were, before the discovery of the passage to the East Indies around the Cape of Good Hope, the first commercial people of the world, have now no commerce of consequence. Coffee, aloes, almonds, the balsam of Mecca, spices, and drugs, and their African imports of myrrh, frankincense, and gum-arabic, are their chief articles of export. Yemen, rich in the costly productions of nature, resorts for a market to Mecca. The Arabian Gulf and the Red Sea connect the commerce of Arabia with that of Africa, especially with that of Egypt and Abyssinia.

From Masuah, in Abyssinia, are exported gold, civet, ivory, rhinoceros' horns, rice, honey, wax, and slaves; and for these the Africans obtain, in Mocha, or Mecca, and Jedda, cotton, cloves, cinnamon, pepper, musk, ginger, cardamom, camphor, copper, lead, iron, tin, steel, turmeric, vermilion, tobacco, gunpowder, sandal-wood, rice, hardware, arms, and a number of other kinds of European manufactures. The exports from Aden, an Arab city, on the straits of Babelmandeb, where many Jews reside for the purpose of trade, are coffee, elephants' tusks, gold, and various kinds of gums, especially gum-arabic; for which it imports chiefly East India and Chinese productions. Muscat, a port in the Arabian province of Oman, the key of Arabia and Persia, carries on considerable trade with British India, Sumatra, the Malay islands, the Red Sea, and the eastern coast of Africa.

Well adapted as the geographical situation of *Persia* is for commerce, it is pursued, nevertheless, with very little energy and little enterprise. Its exports consist mostly of horses, silk, pearls, brocades, carpets, cotton goods, shawls, rose-water, wine of Schiras, dates, wool of Caramania, gums, drugs of various kinds, &c. The chief places for Persian trade are the Turkish

cities of Bagdad and Bassora. The harbour of Abuschar, or Buschir, on the Persian Gulf, is also a mart for Persian and Indian goods. Bagdad, once the centre of a brilliant and extensive commerce, may still be considered as the great mart of the East, though it is by no means what it has been. From Bassora, the productions of Arabia, India, Persia, and the Asiatic islands are sent to Bagdad, where they find a very good market, and from whence they are scattered through the other cities of the Turkish empire. By means of the Arab caravans, Europe supplies Persia with goods of all kinds, and even with the productions of America. On the other hand, it has nothing to give but dates, tobacco, and a very moderate quantity of woollen stuffs, its whole trade consisting in the distribution and sale of the products of other countries. Bassora is, by its situation, the mart of the active East Indian, Persian, and Arabic trade, carried on in the Persian Gulf. Its trade with the East Indies is very considerable, it being the channel through which the Ottoman empire is supplied with the groceries of the East, and with the manufactures of the British possessions in the East Indies.

Asiatic Turkey. The principal port of the Levant is Smyrna, a very important depôt of the merchandize of the East and West. The articles exported from the Levant are coffee, cotton, wool, silk, madder, camels' and goats' hair, hides, raisins, figs, pearls, rotten-stone, whet-stones, nut-galls, opium, rhubarb, and other drugs. Angora sends to Smyrna by caravans, considerable quantities of Angora goats' hair, and stuffs made of the same material; for the Angora goats' hair is manufactured into camlet, in the Levant itself, and in Europe, especially in England, France, and Holland, some of whose camlet manufactories keeps agents in Angora, through whom they make their purchases. Damascus is the centre of trade in Syria, and does a good deal of business through the caravans, which go from the north of Asia to Mecca, and from Bagdad to Cairo. Aleppo has much commercial intercourse with Constantinople, Bassora, Bagdad, Damascus, and Scanderoon, or Alexandria, to which places caravans go every year through Aleppo. Its exports are its own silk and cotton goods, the shawls and muslins of the East Indies, the gall-nuts of Curdistan, copper, pistachio-nuts, and drugs. Alexandria has some trade of importance. Erzerum is the mart of silk and cotton goods, printed linens, groceries, rhubarb, madder, and East Indian zedoary.

The British East Indies, and the Malay Peninsula. For the long period of 4000 years, the products of India, so important in commerce, have remained the same; for all the commodities and treasures of India, mentioned by the ancients, are to this day, those for which the nations of the other quarters of the world resort thither, viz., rice, indigo, cochineal, and other dye-stuffs, opium, cotton, silk, drugs, cinnamon, cassia, cocoa-nuts, &c. The East India trade is mostly in the hands of the English, under the management of the East India Company. Next to the English, the United States are most extensively engaged in the East India trade. Denmark carries on but an inconsiderable trade with the East Indies, and that once carried on by Sweden is now almost annihilated, although, prior to the late great changes in the government of that country, the Swedish East India company was, of all the commercial societies of Europe, the best regulated, and the most successful in its operations, next to the English. The trade of Portugal with the British possessions in the East Indies is of importance; that of Spain, on the other hand, inconsiderable. Calcutta is the most important commercial city of the East Indies. Besides it, Benares, Guzerat, Oude, and Moultan, are worthy of note, among the commercial towns of northern India; Madras and Pondicherry, on the eastern coast; Bombay, Surat, and Cochin, on the western; Goa, &c. From Queda, on the peninsula of Malacca, are obtained tin, rice, wax, fish maws and sharks' fins; at Salengore, Pahang, and Trangano, cloves, nutmegs, pepper, camphor, betel, ivory, gold dust, tortoise-shell, tin, &c. Gold dust is exported chiefly from Malacca. Since 1819, the British government in Calcutta, through Sir Thomas Stamford Raffles, has founded, according to his plan, a new commercial town on the fertile, well-wooded island of Sincapore, on the south extremity of the peninsula of Malacca, on the straits of this name, which is of extreme importance to the British trade with China. and must destroy the China trade of the Dutch. If Sincapore is made a free port, Great Britain will be able to supply from thence the more distant parts of India with the productions of its industry.

China. The trade which China carries on with Europe, British India, the United States of America, Cochin-China, and Siam, with Japan, and the other Asiatic islands, is very considerable. The British imports into China are partly shipped by the East India Company, partly by private merchants. From 1781 to 1791, the company sent thither to the amount of 3,471,521*l.* in goods, and 3,588,264*l.* in bullion; from 1792 to 1809, 16,502,338*l.* worth of goods, and 2,466,946*l.* in bullion. The exports which the company made to England, amounted from 1793 to 1810, including duties, freights, &c., to 41,203,422*l.*, and they were sold for 57,896,274*l.*, leaving the company a net profit of 16,692,852*l.* From the different ports of the British possessions in the East, 35 ships entered the port of Canton in the years 1818 and 1819, and the value of their cargoes was 8,714,272 dollars, and including what was shipped to Macao, the total was 11,999,272 dollars. The exports of the English merchants not connected with the company, to China, probably amount annually to 500,000*l.*—Next to the English, the people of the United States have the most trade with China. Its amount has increased 387 per cent. in 25 years. The exports of tea by the East India Company, in this time, have also greatly increased. The company's export trade from Europe to China has long been stationary. The imports of the nations on the continent of Europe into China consist chiefly of gold bullion, for which tea is received; but these imports are small, since most of them obtain their tea from the English and Americans. With Siam, Cambodia, Cochin-China, the Asiatic islands, and Japan, China has a very active intercourse, and of late, with Russia also, both by land through Kiachta to Irkutsk, &c., and by water. The Dutch, English, and Americans have factories at Canton, the French an agent there or at Macao, the Spaniards an agent at Macao, where the Portuguese have a colony.

From Siam and Tonquin are exported tin, ivory, diamonds, and other precious stones, gold dust, copper, salt, betel, pepper, wax, silk, timber, and lackered wares, and the commerce of these two

countries is mostly in the hands of the Chinese and Portuguese. The trade of Cochin-China is mostly in the hands of the Chinese. The exports are sugar, silk, gold, betel-nuts, ebony, Japan-wood, buffaloes' horns, dried fish, and fish-skins. The Chinese empire is so vast, and the variety of the products of the different provinces so great, that the inland commerce of this world in itself has withdrawn the attention of the people from the foreign trade, which oppressive regulations have injured. Formerly, however, Chinese vessels went to Arabia, and even to Egypt.

Japan. Since the expulsion of the Portuguese from Japan, the commerce of this country has been almost wholly domestic. The only foreigners with whom the Japanese still have any trade, are the Chinese and the Dutch, and these are limited to the single port of Nangasaki. The Chinese supply the Japanese with rice, common porcelain, sugar, ginseng, ivory, silks, nankeen, lead, tin plates, alum, &c.; and in return, receive copper, camphor, lackered wares, pearls, corals, and a metallic composition, called *sowas*, consisting of copper and a small quantity of gold. The Dutch obtain chiefly copper, camphor, lacker, and lackered wares. Only two Dutch, and 12 Chinese vessels are allowed to enter the harbour of Nangasaki annually. After the arrival of a vessel and the performance of the preliminary ceremonies, the goods are sent on shore. Then come the imperial officers (for the trade with foreign countries is the monopoly of the emperor), who examine the quality and the quantity of the goods, deliberate together, and fix the price of the native commodities that are demanded in return. Foreigners must submit to these conditions, or keep the goods which they have brought. The Japanese merchants can obtain foreign goods only by purchasing them of the emperor. In the manufacture of silks and woollens, porcelain, and lackered wares, the Japanese are in no degree inferior to the Europeans. In the manufacture of hardware, they have also attained great skill. The Japanese sabres and daggers are very excellent, and are perhaps surpassed only by the sabres of Damascus. In polishing steel and all other metals, they are also very skilful, and their fine porcelains are much superior to the Chinese. In the beginning of the 17th century, the English began to trade with Japan; but the Portuguese missionaries, and afterwards the Dutch, succeeded in prejudicing the government against them. In 1673, the attempt to renew the trade was again frustrated by the Dutch. On account of the great advantages which it was thought this trade would ensure to England, a third attempt was made in 1699, and the factory at Canton was instructed to enter into connection with Japan, if by any means possible. The result, however, did not satisfy expectation, and all farther attempts have been given up. In 1813, however, when Java was subjected to Great Britain, the East India Company had some slight intercourse with Japan. The Russian mission to Japan, under Krusenstern, in 1805, was no less unsuccessful than the English had been.

The Islands of Amboyna, Banca, the Bandas, Java, Sumatra, Borneo, &c.—From Amboyna are exported cloves, to confine the cultivation of which solely to this island, the Dutch took great pains to extirpate all the clove-trees on the neighbouring islands. For this purpose, also, the government of Amboyna, with a numerous retinue, still makes a journey every year to the other Dutch islands. Banca is celebrated for its tin mines, and the exportation of this tin to China is of much importance, as the Chinese prefer it to the English on account of its malleability. About 4,000,000 pounds of tin are obtained annually. The Banda islands produce nutmegs and mace. The staple exports from Batavia, where all the goods of the Dutch East India company are deposited, are pepper, rice, cotton, sugar, coffee, and indigo. 6,250,000 pounds of pepper, part of which is raised on the island itself, part brought from Bantam, Sumatra, Borneo, and the other islands, are annually stored in the magazines. Both coffee and sugar have also been cultivated here, of late years, to the amount each of 10,000,000 pounds. Borneo has, besides pepper, gold in dust and bars, wax, sago, camphor, the last of the most excellent quality. In addition to the Dutch and English, the Chinese have here an active trade. The exports of Ceylon are cinnamon, pepper, coffee, tobacco, betel, cocoa-nuts, drugs, timber, pearls, precious stones, corals, &c. Of the Philippines, the principal are Lucon or Manilla, and Magindanao or Mindana. The exports are indigo, sugar, silk, gold dust, quassia, pepper, tortoise-shell, wax, precious stones, silver, sago, and tobacco. The trade of the Philippines with China and South America is considerable. Manilla produces sugar, the best Asiatic tobacco, indigo, and a kind of hemp. The Prince of Wales' Island, from its situation between India, China, and the Eastern isles, has an important trade. Its exports are chiefly benzoin, pepper, betel-nuts, groceries, metals, East India zinc, cochineal, eagle-wood, Japan-wood, elephants' teeth, sugar, and silver bullion. Sumatra carries on considerable trade. The exports are gold dust, betel, benzoin, pepper, camphor, Japan-wood, sulphur, rattans, wax, gum-lac, groceries, tin, &c.

III. Africa. The want of navigable rivers, and the immeasurable deserts by which the fruitful regions of Africa are separated, form an insurmountable obstacle to that extension of commerce which the great fertility of this quarter of the globe would promise. In addition to the intercourse of the interior, the commerce of Africa has its sources in Egypt, the Barbary states, on the west coast in Guinea, in the neighbourhood of the rivers Gambia, Niger, and Senegal, at the Cape of Good Hope, and the Portuguese colonies, and on the coasts of the Red Sea. The inland trade is carried on by means of caravans. The African caravans consist of from 500 to 2000 camels. The three principal countries from which they proceed are Morocco, Fez, and Egypt. The chief articles of the inland trade of Africa are salt, gold, and slaves. The greatest caravans go from the western coast and from the interior by way of Timbuctoo, the great mart of the inland trade, and other places of depôt, to the eastern coast, where the most important commercial places are Natal (on the coast of Lagoa), Soffala, Quilimane, Mozambique, Querimba, Quiloa, Mombaza, Melinda, Brava, Magadoxo, Berbera, Zeila, and Adel. Quilimane, Mozambique, and Melinda, are Portuguese settlements. From Adel, Zeila, Berbera, and Brava, are exported, mainly, gold dust, ivory, and incense, for which the products of Arabia and the East Indies are returned. There is a considerable trade between the British settlements in the East Indies and Mozambique, and the English obtain elephants' and hippopotamus' teeth, tortoise-shell, drugs, cowries, gold, &c.

The Barbary States. The commercial intercourse of the Barbary states with Europeans is very inconsiderable and vacillating, and the little business which is transacted is mainly in the hands of the French, British, and Americans. The exports consist of olive-oil, wax, wool, wheat, gums, almonds, dates, aromatic seeds, ivory, leather, hides, and ostrich-feathers. Even the coral fisheries on the coasts (from Cape Rosa to Cape Rouax) are in the hands of the French and Italians; and the annual produce of about 50,000 lbs. of coral is worth more than 420,000 dollars. But a far more important commerce is pursued by the Barbary states with Arabia, Egypt, and the interior of Africa. Their caravans are met with in Mecca, Cairo, and Alexandria. The chief commercial cities are Algiers, Tunis, Tripoli, Sallee, and Agadeez, or Santa Cruz, and in Morocco, Mogadore. Before the French revolution, the commerce of Algiers was wholly in the hands of a company of French merchants at Marseilles, who had regular settlements in the ports of Bona, La Calle, and Il-Col. But, in 1806, the dey conveyed, for 50,000 dollars, the possession of those ports to England. The chief ports of export of Algiers are Bona and Oran. Tunis is the most important commercial state in Barbary. Its chief harbours are Biserta, Susa, and Soliman. Tripoli has little trade, and its exports consist mostly of saffron, ashes, senna leaves, and madder. The trade of Morocco and Sallee is also of little importance. Agadeez, or Santa Cruz, is the most southerly harbour of Morocco, and was once the centre of a very important trade. Fez is still such a centre between the ports of Morocco, the Mediterranean Sea, and the interior of Africa.

Cape of Good Hope. The trade with the Cape of Good Hope is extremely advantageous to Great Britain. In 1809, the importation of English goods exceeded 330,000*l.*, while the exports of the colony (mostly Cape wine) did not amount to 6,000*l.* The amount of the trade has since been very much enlarged by the increase of colonization. The average exports from Great Britain to the Cape of Good Hope amounted to 2,119,000 dollars, and the imports into England from the Cape to 1,561,000 dollars.

Egypt. From its uncommonly favourable situation, in the centre of three portions of the globe, this country seems destined by nature to be also the centre of their commerce; but it has altogether lost its former high rank in the commercial world, since it has ceased to be the channel of the India trade. It has, nevertheless, considerable inland trade, which extends into the interior of Africa. Three caravans go thither, every year, from Egypt. One goes to Sennaar, and collects the productions of this country and Abyssinia; another to Darfour, and the third to Fez, whither the productions of Bornou, and all the countries lying along the Nile, are brought. Other caravans exchange Egyptain commodities for those of the East Indies and Arabia. But the most considerable is that which consists of the united caravans of Abyssinia and Western Africa, and goes annually to Mecca. The exports of Egypt are rice, corn, cotton, myrrh, incense, opium, dates, mother-of-pearl, ivory, gums and drugs of various kinds, hides, wax, &c., most of which go to Constantinople, the Barbary states, Great Britian, Venice, and Marseilles. It also exports the productions of Arabia. The chief commercial cities are Cairo and Alexandria, united by a complete canal since 1819. Cairo has two ports, Rosetta and Damietta. France sends to Egypt woollen cloth, red caps, fringes of all kinds, and ornaments of dress, ordinary china ware, arms, &c. England sends muslins, and cloths of different kinds, alum, iron, lead, vitriol, gums, &c. From Florence silks are imported.

Guinea. Sierra Leone, and the Pepper, Ivory, Gold, and Slave Coasts, where the Dutch, French, English, and Danes have settlements, export gold dust, ivory, gums, hides, &c., and formerly slaves, in exchange for woollen and cotton goods, linen, arms, gunpowder, &c. The coasts of Lower Guinea (Congo, Angola, &c.), and the Guinea Islands, mostly occupied by the Portuguese, export grain, provisions, cotton, indigo, sugar, &c. The slave trade is here prosecuted still by the Portuguese.

Among the other *African Islands*, the Azores raise, for exportation, wine and fruits. About 20,000 pipes of the former are annually exported by the English and Americans, chiefly to the East and West Indies. The Island of St. Michael sends, every year, to England and the United States, 60 to 80,000 boxes of oranges. The oranges of the island of Pico are remarkable for their superior quality. This island also produces a beautiful kind of wood, which is almost equal to mahogany. The staple productions of the Canaries are archil, in its raw state, rosewood, brandy, and Canary wine. The last goes chiefly to the West Indies and England: in the latter country it is always sold for Madeira wine.

The Cape Verd Islands export archil in a raw state, and coarse cotton cloth for the use of the Africans. The staple produce of Madeira is valuable wine, which is divided into five kinds, according to the market for which it is designed. The most excellent is called *London particular*. The next in quality is also sent to the London market. Of inferior quality is that destined for the India market. The kind that goes to America holds the fourth rank, and the fifth is designated by the name of *cargo*. Of this wine the English annually receive more than 7000 pipes; the United States about 3000. The Isle of Bourbon produces coffee, cloves, white pepper, cotton, gums, benzoin, and aloes. Its trade is confined almost wholly to Madagascar, Isle de France, the Comoro Islands, and the settlements of the Arabs on the eastern coasts of Africa. The Isle de France, or Mauritius, exports coffee, indigo, cotton, sugar, nutmegs, cloves, ambergris, &c. The exports of Madagascar are cowries, betel-nuts, ambergris, wax, cocoa-nuts, and corn.

IV. America. The extensive coasts of America give it all the commercial advantages of the ancient world, free from the obstacles presented by those masses of continents, the interior of which is so remote from the sea, and destitute of navigable rivers, like the whole of Africa and the boundless tracts of Asiatic Tartary and Siberia. In the abundance of navigable rivers, both North and South America have an immense advantage over the other quarters of the world. The long chain of great lakes and numerous navigable rivers in North America are already the theatre of a very active commerce. The great inland countries of South America are rendered accessible by rivers of gigantic magnitude, and from the mouth of the River Plata to the Gulf of Darien, an inland navigation may be effected, almost without having recourse to the aid of art. But there still remains, for the promotion of American commerce, the execu-

tion of a great work—the digging through the narrow isthmus of Darien—by which a connection between the Pacific and Atlantic would be effected, the advantages of which would be incalculable. The western passage to India, which Columbus sought for, would then be effected. Alexander Von Humboldt points out three places as most adapted to the execution of such a project. Nature herself seems willing to assist, for, though the mountains forbid the idea of forming a canal immediately across the isthmus, yet, by starting in lat. 12° N., joining the head of lake Nicaragua to a small river which runs into the Pacific Ocean, and forming a canal 30 miles long, through a low level country, a communication between the two oceans might be effected. The governments which are most directly interested in making such a canal are at present too weak and too unsettled to be able to carry it into effect; yet Bolivar appeared to have always had this great work in view.

The United States of North America. The rapid progress which the United States have made in commerce and navigation is unparalleled. Hardly had this people appeared on the ocean before every coast of the earth was visited by their navigators. While they are seen covering the ocean with their vessels throughout the Atlantic coast, even to Cape Horn, whence they enter the broad Pacific; in the other direction, they press on to the ice of the North Pole, and penetrate the deep recesses of Hudson's Bay and Davis's Straits. The most remote and dangerous seas are traversed by their keels. The coasts of the whole southern hemisphere, the western coast of America, and the eastern coasts of Asia, are visited by them. It is a very common thing for an American merchantman to make a voyage round the world, starting from the United States, going round Cape Horn to the north-west coast of America, taking in furs, sailing to China, and going from thence with tea, &c., to the ports of Europe. The American whalers are distinguished for skill and boldness.

Agricultural Exports. The trade of the United States, for the year ending September, 1828, may be assumed as the basis of the remarks to be made upon the subject of this commerce. The exports of domestic products for that year, according to the custom-house estimates, were 50,669,669 dollars. Those of cotton, the great staple of the country, were 22,487,229 dollars, and, accordingly, nearly half of the entire amount. The next greatest export is that of tobacco, which amounted to 5,269,960 dollars. Of rice, the export amounted 2,620,696 dollars. The value of these three articles, being over 30,000,000 dollars, thus constituted three-fifths of the whole. In the annual returns made to Congress, the exports of domestic products are divided into those of the *sea*, the *forest*, *agriculture*, and *manufactures*. The three species of agricultural articles above mentioned are mostly the productions of the Southern States, including Virginia and Kentucky. The other exports, coming under the same head, are mostly furnished by the Middle and Western States: namely, beef, tallow, hides and cattle, butter, cheese, pork, bacon and hogs, horses, mules, sheep, flour, biscuits, corn-meal, rye-meal, oats, potatoes and apples, flax-seed, and hops. Of these articles, the principal is flour and biscuit, the value of which was 4,464,774 dollars, being the third article in value among the exports. The fifth article in value is that of swine and their products—viz., bacon, pork, and lard, the value of which was 1,495,830 dollars, making about one thirty-third part in value of the whole export. The articles of corn-meal and rye-meal amounted to 881,894 dollars, constituting a little more than one-sixtieth part of the whole exports. Cattle and their products, including butter and cheese, exceeded the last amount, being 896,316 dollars. This species of export is of far less comparative importance in the trade than formerly, being limited to its present amount, not by the capacity for production, but by the extent of demand in the foreign markets; for an increase of the foreign demand would very soon double and treble the quantity. Some of the articles comprehended in the above list, though agricultural products, yet involve some process of manufacture; such, for example, as butter, cheese, bacon, flour, biscuit, meal, and part of the tobacco. A great many, however, of the exports coming under the head of *manufactures*, include in them the value of materials supplied by agriculture, such as the cotton fabrics, those of leather, and spirits distilled from grain; so that, on the whole, the strictly agricultural products of the country constitute a larger proportion of the whole exports than the tables represent; and yet the proportion represented by the tables is very large, being 38,500,000 out of the 50,000,000; and, if we add the value of the materials supplied by agriculture for the manufactured exports, we shall have at least six-sevenths of the whole domestic exportation, consisting of the raw products of agriculture.

Products of the Sea. The products of the whale, cod, mackerel, and herring fisheries, exported mostly from the Northern States, amount to 1,693,980 dollars, being nearly a thirtieth part of the whole domestic export. Nearly one-half of this value consists of codfish, and more than one-third of the products of the whale-fisheries.

Products of the Forest. The value of skins, furs, ginseng, lumber, staves, bark, tar, pitch, rosin and turpentine, and pot and pearl ashes, partly from the Northern and partly from the Southern States, which were formerly of much greater comparative importance in the trade of the country, now constitutes about one-thirteenth part of the whole value of the domestic exports, and amounts to 3,889,611 dollars. A large proportion of the trade in these articles, as well as in those of codfish and bread-stuffs, is carried on with the West Indies, Mexico, and South America. The skins and the furs go to Europe and Canton; the ginseng to Canton, but in less quantity than formerly, being, in 1828, but 91,164 dollars; and the pot and pearl ashes are sent to England and France.

Manufactures. The manufactures are, as yet, of the coarser sort, consisting partly of articles made of the products of the country, and partly of those fabricated from foreign materials. But it is obvious that the arts of the country, in their early stages, will be most naturally directed to the working of the raw materials of domestic production; and we accordingly find, that a very small part of the value of exported manufactures consists of the cost of raw materials previously imported. The articles in which the foreign materials form a considerable part of the value are spirits manufactured from molasses, refined sugar, articles of iron, cordage, chocolate, gunpowder, umbrellas and parasols, gold and silver coin, and jewellery.

The whole estimated value of exports of home manufactures is about 6,500,000 dollars, being about 13 per cent. of the whole domestic exports of the country. About 700,000 dollars of this amount ought to be struck out of the list of domestic exports, being gold and silver coin, consisting mostly of metals imported from abroad, and, after being coined at the mint, again exported. The labour put upon these materials, in coining, is so inconsiderable a part of their value, that the value of the coin of the country exported ought not to be included in the estimate of the value of domestic exports. Considerable quantities of gold, it is true, have been produced in North Carolina, but by no means enough, as yet, to supply the demand for the consumption of the country, though it is to be considered, at the same time, that this article, as far as it can be supplied from the domestic mines, will tend directly abroad, being drawn into this channel by the higher price of gold, compared with silver, in England and France than in the United States; the value being in England, at $15\frac{6}{10}$, in France as $15\frac{66}{129}$, and in the United States, as $15\frac{11}{27}$ to 1. Consequently, the gold, whether in coin or bullion, tends strongly to leave the country. Some of it is arrested for use in jewellery and the arts, but very little in the currency or in the vaults of the banks. Omitting this article, then, the other articles above enumerated, being the only ones the value of which is made up, in any considerable degree, of foreign materials, are valued in the returns, at 683,000 dollars. The value of materials imported, and then wrought up in manufactured articles, and exported, and included in the list of domestic manufactures, may be estimated at about 200,000 or 250,000 dollars; leaving the net exports of manufactures from the raw products supplied by the country about 5,750,000 dollars. As cotton fabrics form a large item in this list of exported manufactures, and those fabrics are mostly of the coarser kind, the raw material will constitute a very considerable part of their value, and the proportional value of the direct wages of manufacturing labour, incorporated in these exports, will be proportionally less. If, for instance, a plough, or trunk, or quantity of combs, be sent abroad, almost the whole value of the export consists of the wages of the manufacturers; and a still greater proportion of the value of earthen and stone wares, which make a very considerable item in this list, is of this description; whereas an export of spirits distilled from West India molasses comprises a comparatively small proportional value of manufacturing labour. Taking the whole list of domestic manufactured articles together, and making allowances for the cost of the raw materials, in their rudest state, after they are taken from the ground or from animals, and assume the character of merchandize, by deducting their value from the gross amount of that of the exported manufactures, the remainder, which is the result of the manufacturing labour, interest of capital, and profits incorporated into these materials, to bring them into the state in which they are exported, may be estimated at about 4,000,000 dollars. We will now glance hastily at the descriptions of articles on which the arts of the United States are employed for the supply of foreign markets; and the most considerable of them is cotton twist, thread and fabrics, the exported value of which, for the year 1828, was 1,000,000 dollars and a fraction over, being one-fiftieth part of the whole domestic exports, the principal markets of which are South America, Mexico, and the Mediterranean. The value of leather, and its various manufactures, exported, is a little over 500,000 dollars, making one per cent. of the entire exports of the description of which we are speaking. The value of hats exported during the same year was about 333,300 dollars—a very large amount, considering the short period since this article has been sent to foreign markets. Soap and candles have long been supplied for the foregin markets, the amount for the year in question being about 900,000 dollars. The various articles manufactured, for the most part, of wood, such as furniture, or of wood, leather, and iron, such as coaches and carriages, besides various agricultural implements supplied to the West Indies and South America, constitute a very important branch of trade, which amounted to between 600,000 and 700,000 dollars. The American glass begins to appear in the foreign markets. The value sent abroad in 1828 was 51,452 dollars, and it bids fair to be increased. The other exports consists of a variety of articles in small quantities, among which are, wearing-apparel, combs and buttons, brushes, fire-engines and apparatus, printing-presses and types, musical instruments, books, maps, paper and stationary, and trunks. It is apparent, from the above enumeration and estimates, that the manufactured articles, of which the export is most considerable and the most flourishing, are those of which the raw materials consist, mostly, of cotton, wood, and leather.

Foreign Exports. The foreign articles imported and again exported from the country, during the same year, amounted to 21,595,017 dollars. This transit trade thus appears to form a very important part of the American commerce. But one-third of this whole amount consists of an article which affords very little freight, namely specie, the export of which during the same year, was about 7,500,000 dollars. Another large item in value, of this transit trade, consists of cotton fabrics, the exports of which were 2,000,000 dollars. The foreign silks exported amounted to about a quarter as much. The value of wines exported was about 333,300 dollars; that of teas about twice as much; and that of coffee and cocoa 1,500,000 dollars, and of sugar nearly 1,000,000 dollars. These are the most important articles of foreign export. The other exports of foreign articles previously imported amounted, during the same year, to about 8,000,000 dollars in the whole; but it is not necessary to enumerate them.

Imports. The imports, for the same period, according to the custom-house estimates, amounted to 88,589,824 dollars, and exceeded the estimated value of the exports by about 16,250,000 dollars. There should, of course, be an excess of value of imports, according to those returns, whether their value is estimated at the cost in foreign ports, or at the market-price in the American ports; for these goods are the returns for the exports, the value of which is estimated at the rate of the markets in the United States: and unless a greater value of merchandize can be obtained in exchange, in the foreign ports, the ship-owners would obtain nothing for outward freight: and still more ought the value of the imports in the American markets, after deducting duties, to exceed that of the exports; for this excess is the only fund for paying the two freights and interest on the capital employed. This excess, for the year in question, was about 22 per cent., which cannot, however, be considered very exact, but is probably below the actual rate. That

it must be a large amount, in order to save the merchants from loss, is evident; for the registered tonnage, which is mostly employed in foreign trade, is about 750,000 tons, so that an excess of 16,000,000 dollars in the value of imports over that of exports, supposing an exchange of one for the other, would give only about 21 dollars per ton, per annum for the shipping employed—an amount scarcely sufficient to defray the expenses of the navigation, including port-charges, and leave a surplus for interest on the capital invested in the cargoes, and a small profit to the merchant. But the rate per ton for the shipping actually employed in the foreign trade, if we estimate the accession at 16,000,000 dollars, and supposing the whole trade confined to American ships, will exceed that above mentioned, since the registered vessels are partially employed in the coasting-trade, as vessels often take a cargo from one-home port to another, whence a cargo is taken for exportation. But a part of this trade requires none of the excess, of which we have been speaking, to defray the expenses of navigation, for about one-thirteenth part in value is carried on in foreign bottoms, the imports in which were about 6,500,000 dollars. If the whole trade were carried on by foreign shipping, and the whole were a barter trade, without credits, as the trade between any two nations, or any number of nations, must in effect be, in the long run, the value of exports and imports, estimated at the prices in the home market, after deducting duties paid on importation, must be just equal; for in the case supposed, all the expenses of transportation are defrayed by the foreign ship-owners. In proportion, therefore, as foreign shipping is employed in the trade, the excess of the value of imports over that of exports will be reduced; since, if a country employs foreign shipping in its trade, it must export an additional value of merchandize to pay the freights, or import a smaller value of merchandize in exchange for the same exports. In regard to the various kinds of goods imported, without pretending to great exactness, which is the less important as the proportions vary considerably from year to year, it appears that some of the principal articles have constituted nearly the following proportion of the whole imports, previously to 1828; viz.—wool and woollen fabrics, 11 per cent.; cotton stuffs, 12; silk, 10; hemp and flax, and manufactures of them, 5; iron and steel, and manufactures of them, 5; spirits, 1¼; molasses, 2½; teas, 4; coffee, 3½; sugar, 5½; and indigo, 1½ per cent.

The principal trade, both import and export, is with Great Britain and its dependencies, whence, in 1826, the imports were forty-two ninety-sixths of the whole importation. But to state, even in a general manner, the species of merchandize of which the commerce to and from each country principally consists, would extend this part of the present article to too great a length. Before closing it, however, we should not omit to remark, that the domestic trade of the country is more extensive and more important than the foreign. That it is more extensive, appears from the returns of the shipping, a greater quantity of tonnage being employed in the coasting trade and fisheries than in the foreign commerce; and as these vessels make from 3 to 10, 12 or 20 passages in a year, according to the distance of the ports between which they trade, the amount of commercial exchanges along the coast, and up the rivers to the head of sloop navigation, without including the trade between the coast and the interior, must greatly exceed the foreign commerce.

From the official report of the treasury department, it appears, that the imports into the United States, during the year ending September 30, 1829, amounted to 74,492,527 dollars, of which amount 69,325,552 dollars were imported in American vessels, and 5,166,975 dollars in foreign vessels; that the exports, during the same year, amounted to 72,358,671 dollars, of which 55,700,103 dollars were of domestic produce, and 16,658,478 dollars of foreign produce; that of domestic articles, 46,974,554 dollars were exported in American vessels, and 8,725,639 dollars in foreign vessels; and of the foreign articles, 15,114,887 dollars were exported in American vessels, and 1,543,591 dollars in foreign vessels; that 872,946 tons of American shipping entered, and 944,799 cleared, from the ports of the United States; and that 130,743 tons of foreign shipping entered, and 133,006 cleared, during the same period.

THE CANADAS, NOVA SCOTIA, AND NEW BRUNSWICK. The trade of the two Canadas was long confined to the bare produce of the fisheries and the fur trade. But, in consequence of the improvement of the British colonial system, and of the embargo which was imposed on the American trade during the last war of the United States with Great Britain, it has much increased. Its exports are wheat, flour, corn, biscuit, fish, oak and pine timber, staves, masts, lumber, Canadian balsam, spruce-beer, pot and pearl ashes, cast-iron, furs and skins, castoreum, ginseng, &c. The imports are wine, rum, sugar, molasses, coffee, tobacco, salt, coal, and British manufactures. Since 1825, the trade of Canada has increased rapidly. The trade is mostly with the British West India colonies and with the mother country. They do some business, however, with the United States. The trade which they have with the Indian tribes, consists merely of barter.—Nova Scotia, and New Brunswick, have nearly the same exports.

MEXICO. The commerce of Mexico is at present checked by natural and political causes. The want of river communication is a great impediment to its internal commerce. Roads lead from the *plateaux* to the seaports, but they are very imperfect, and beasts of burden, therefore, are preferred to carriages, which would not be able to make their way. The principal objects of export are gold and silver, either in bullion, coined, or worked up in various ways; cochineal, sugar, flour, indigo, salt meat, dried vegetables, tanned hides, sarsaparilla, vanilla, jalap, soap, Campeachy wood, and pimento of Tabasco. Among the articles imported are woollen cloths, silks of Lyons, linen from Germany, white and printed calicoes from France, England, and the United States, paper, china, spirits, cacao, quicksilver, iron, steel, wine, wax, jewellery, watches and clocks, and all kinds of ornaments. In 1826, 1267 vessels entered the ports of the republic. The chief port of Mexico is Vera Cruz. Mexico, the capital, is a commercial place, as we might easily suppose to be the case in a country in which very little is manufactured, and which is so fertile. A part of the commerce of the United States with Mexico is carried on by means of caravans, which go from the state of Missouri to Santa Fé, in Texas. The smuggling trade in Mexico is very great. The chief commercial cities of Mexico are Acapulco and Vera Cruz. Acapulco, or Los Reyes, carries on

a considerable trade with the Philippines, and the coasts of Quito and Peru. To Manilla a galleon used to be sent from this port every year, freighted with silver, cochineal, cacao, sweet-oil, Spanish wool, and European toys. This brought back muslins, printed linen, silks, Chinese goods, groceries, spices, and precious stones. Guatimala is celebrated for its indigo, which is noted for its hardness, lustre, and weight.

South America. South America has many articles of trade. The mineral treasures of the country are boundless. In the 16th century, gold and silver existed in such profusion, that, for 25 years, 13,000,000 dollars are said to have been annually exported to Spain from Peru alone, exclusive of what was sent in bars. These precious metals are found throughout Peru, Chili, and the upper section of Tucuman, especially in the Cordilleras; but, in addition to gold and silver, this immeasurable chain of mountains affords copper, lead, iron, and platina. The richest mines of South America are those of the province Las Charcas, in the territory of the former viceroyalty of Buenos Ayres. There are, in that district, 30 gold mines, 27 silver mines, 7 copper, 1 tin, and 7 lead mines. The richest of these mines are those of Potosi, which are situated near the sources of the La Plata. Acosta's account, that, during 40 years that the mines had been wrought, they had yielded 12,000,000,000 dollars, is much exaggerated. But we gather from official reports, that, from the time of the discovery of America till 1538, the fifth part, accruing to the king, of all the silver obtained from the mines of Potosi, and registered, amounted to 395,619,000 dollars; so that, when 39 years had elapsed from the discovery of America, 41,255,043 dollars were obtained annually, exclusive of the considerable quantities which undoubtedly were conveyed from the country secretly, and without the payment of duties, and of that which was used for making silver vessels, images, and ornaments for the monasteries and churches, which must have amounted to an immense sum, since all the religious establishments in the country, and especially in the city of Potosi, were very rich in silver vessels. But, whether owing to the exhaustion of the mines themselves, or the faulty management of them, the profits have since diminished. The other exports from South America, although the Spanish and Portuguese directed their chief attention to the obtaining of metals, are very considerable. The following are the principal: cochineal, indigo, cacao, the Peruvian bark, hides, ox horns, tallow, wax, cotton, wool, flax, hemp, tobacco, sugar, coffee, ginger, pimento, jalap, sarsaparilla, ipecacuanha, guaiacum, dragon's blood, and various other medicinal gums, dye-wood, ebony, mahogany, emeralds, various kinds of balsams, &c.

The chief commercial cities of South America are Rio Janeiro, Buenos Ayres, Lima, Carthagena, Caracas, Potosi, and Bahia. Buenos Ayres was in possession of the transit trade of all the Spanish possessions in America, and, before the beginning of the revolution, was the mart of the trade of the mother country and its colonies. The principal source of gain for Caracas is the cacao plant, as it supplies nearly two-thirds of the European demand. The hides and skins which it exports are superior to those of Buenos Ayres; and the rich ore from the copper mines of Aroa is superior to the Swedish, or to that of Coquimbo, in Chili. The internal trade of South America, especially between Buenos Ayres and Peru, is very considerable. That with the Indian tribes is chiefly in the way of barter; axes, knives, scissors, swords, necklaces, mirrors, and coarse cotton and woollen goods, being exchanged for the productions of the country, especially the celebrated Paraguay tea, and some fine furs.

Brazil has three great commercial cities—Rio Janeiro, Bahia, or St. Salvador, and Pernambuco. The exports are, chiefly, cotton, indigo, sugar, coffee, rice, tobacco, tallow, mahogany, Peruvian bark, ipecacuanha, hides, gold, cacao, vanilla, the diamond, the topaz, chrysolite, amethyst, and other precious stones, and a great variety of dye-stuffs, balsams and gums, dried beef, and India-rubber shoes. The greater part of the Brazilian trade is in the hands of the English. The imports are iron, steel, copper utensils, salt, woollen cloths, linen, calicoes, hats, shoes of all kinds, china, glass-ware, trinkets, books, paper, watches, clocks, and particularly East India goods, such as are not raised in Brazil. Portugal sends to Brazil wine, oil, spirits, hats; the United States, send flour, turpentine, and furniture. Naval munitions, sailors' clothes, and arms, are likewise imported.

Colombia, consisting of Venezuela and New Grenada, says Alexander Humboldt, has received from nature a greater and richer variety of vegetable products, suited for commerce, than any other country of Spanish America; yet its commerce has been declining every year since its separation from Spain. In Colombia, Peruvian bark is found of the best quality, and in the greatest quantity. Coffee, indigo, sugar, cotton, cacao, ipecacuanha, the tobacco of Varinas, hides, and dried meat, pearls, gold, platina, &c., are obtained in this highly favoured country. Its imports embrace all kinds of manufactured goods, oil, soap, ropes, paper, in fact almost every thing which is wanted by the indolent inhabitants, and made by the hands of men; for the people themselves manufacture hardly any thing. Humboldt has estimated the exports of Colombia at 9,000,000 dollars, and its imports at 11,200,000 dollars. M. Mollien estimates the former at 8,000,000 dollars, and the latter at 10,000,000 dollars. The state of this country, at the present moment, prevents the possibility of obtaining accurate information on this subject. The ports of La Guayra (harbour of Caracas), Rio del Hacha, St. Martha, Carthagena, Chagres, Porto Cabello, Panama, and Guayaquil, are the most frequented by strangers. The English, from Jamaica, the Americans and French, are the nations who trade principally with the Colombians in the Atlantic ports; the Peruvian vessels carry on the coasting trade of the Pacific.

Buenos Ayres, like all the other South American states, is in an unsettled condition. The chief exports of this country are horse and ox hides: in fact, Buenos Ayres may be called, by way of eminence, the country of cattle. Its imports include all the manufactured articles which the inhabitants make use of. England sends thither woollen and cotton cloth, cutlery, hardware, furniture, saddlery, hats, porter, and cheese; the United States, lumber, cod-fish, mackerel and herrings, leather, gunpowder, provisions; from Brazil are sent sugar, coffee, cotton, rum; steel and iron, from the north of Europe; and France sends her manufactures. The exports and imports are estimated at 9,000,000 dollars.

The commerce of *Chili* is, at present, in a low con-

dition. Its rich mines are poorly managed, and the political state of the country prevents its commerce from acquiring that activity which it might easily attain by the export of the precious metals of the country to the East Indies, to give in return for sugar and cotton. It could also provide Peru with salt meat, and take in return coffee, sugar, &c. Caldcleugh estimates the English importations into Valparaiso, in 1822, at 4,071,250 francs, and Lowe at 47,248,625 francs, for the same year. The United States send thither flour.

Peru trades with the United States, with Europe, the Philippine islands, Guatimala and Chili, and by land, with Buenos Ayres. Its exports are chiefly gold and silver, wine, brandy, sugar, pimento, Peruvian bark, salt, vicuna wool, and coarse woollens.—It receives in return, from the United States, breadstuffs and manufactures of various sorts; from Europe, manufactured goods, particularly silks, fine cloth, lace, fine linen, and other articles of luxury und show; from the Philippine islands, muslins, tea, and other East India goods; from Guatimala, indigo; from Chili, wheat and copper; and from Buenos Ayres, mules and Paraguay tea. Calao is the port of Lima.

The commerce of *Central America*, or Guatimala, is increasing in activity. Colonial commodities, chiefly sugar, coffee, cacao, cotton, indigo, cochineal, ebony and logwood (from the bay of Honduras), are the principal exports sent to Europe and some of the United States. The imports are linen, from Germany and France; woollen cloths, silks and wines, from France; English and French calicoes; flour, and some manufactured goods, from the United States. This country is well adapted for commerce, on account of its fine harbours and several navigable rivers. A canal across the isthmus would be of vast benefit to this country; in fact, the execution of such a canal would bear a similarity to some of those great inventions, which have changed the face of the world.

The English, Dutch and French possessions in South America are *Demerara, Berbice, Essequibo, Surinam,* and *Cayenne*. From Cayenne are exported cloves, Cayenne pepper, annotta, sugar, cotton, coffee, and cacao; from Berbice, rum, sugar, cotton, cacao, &c.; from Demerara, Surinam, and Essequibo, sugar, rum, cotton, coffee, and molasses.

West Indies. The chief islands which constitute the West Indies are Cuba, St. Domingo, or Hayti, Jamaica, Barbadoes, Dominica, St. Christopher, or St. Kitt's, Curaçao, and Guadaloupe. They have all very nearly the same productions, viz. sugar, coffee, wax, ginger and other spices, mastich, aloes, vanilla, quassia, manioc, maize, cacao, tobacco, indigo, cotton, molasses, mahogany, long peppers, lignum-vitæ, Campeachy wood, yellow wood, gums, tortoise-shell, rum, pimento, &c. Before St. Domingo or Hayti became an independent government of blacks, it was the depôt of the goods brought from Havannah, Vera Cruz, Guatimala, Carthagena, and Venezuela; but, since that event, Jamaica has been the magazine of all goods from the Gulph of Mexico. Trinidad is the great seat of the contraband trade with Cumana, Barcelona, Margarita, and Guiana. The imports are manufactures of all kinds, wine, flour, and, formerly, slaves, who are still smuggled into many of the islands. The West Indies form one great source of the commerce of the world; and we must refer the reader, for more particular information, to the articles on the different islands.

A new path has been laid open to the commerce of the world by the British, in the Southern ocean, where, of late, the Sandwich, the Friendly, and the Society islands have been taken within the circle of European and American intercourse; and in Australia and Van Diemen's Land, a great market has been established for the exchange of British manufactures for the productions of nature; while the North Americans have attempted to found commercial settlements on the Washington (Nukahiva) and other islands of the Pacific, where they have pursued a system of trade, as honourable and creditable to their merchants, as it will be ultimately beneficial to their country.

Commission. The rule known in commercial arithmetic by the name of commission, is identical with that of brokerage, and reposes on the same principles with interest, discount, insurance, and a variety of other rules, which are usually made the subject of distinct consideration in most of our treatises on arithmetic. It is frequently necessary in mercantile transactions, for one individual to employ another to effect a sale or purchase which he is himself prevented from making. In all commercial communities this employment is generally assigned to a separate class, called brokers, or commission agents, and the remuneration which they receive for their services is termed brokerage, or commission. The amount of this commonly depends on the value of the property bought or sold, for every 100*l.* of which the broker charges a certain sum, determined according to established usuage or special agreement. If this sum be 1*l.* the *rate* of the commission is said to be 1 *per cent.* (per cent. being a contraction of *per centum*, which is the Latin of *for an hundred*); if 2*l.* it is said to be 2 per cent. or 2*l.* for every hundred; if 3*l.* 3 per cent., and if $\frac{1}{2}$*l.* or 10*s.*, it is termed half per cent.

It is very easy to ascertain what is the commission to be paid on any transaction. As the agent is to have a certain sum (according to the rate agreed upon) for every 100*l.* contained in the amount of the sale or purchase he has effected, the whole commission will be that sum taken as many times as there are 100*l.* in that amount. Thus the commisison on 500*l.* at 2 per cent. will be 10*l.*; for there are five *one hundred pounds* in the amount 500*l.*, and $5 \times 2 = 10$. Hence we deduce the following rule:—Divide the amount of the sale or purchase by 100, and multiply the quotient by the rate of the per centage.

Let us take an example, to find the commission on 339*l.* at $2\frac{1}{2}$ per cent.; employing the decimal note line, we have

$$\frac{339}{100} \times 2\tfrac{1}{2} = 3.39 \times 2.5 = 8.475$$

and converting the fractional parts of a pound into shillings and pence, this result becomes 8*l.* 9*s.* 6*d.*

Commodore; a general officer in the British marine, invested with the command of a detachment of ships of war destined for any particular enterprize. He retains this title only during the continuance of the expedition, during which he has the rank of a brigadier-general in the army, and his ship is distinguished from others in his squadron by a broad red pendant. The eldest captain of three or more vessels cruising in company is often c alled *Commodore* by courtesy. In the United States, the title *commodore* is only given by courtesy, not officially.

Commodore Ship, in a fleet of merchantmen, is the convoy and principal ship, which leads the other vessels, and keeps them together, bearing a light in her top.

Company, in military language; a small body of foot or artillery, the number of which varies, but in the English army is generally from 50 to 120, commanded by a captain, a lieutenant, and an ensign, and, sometimes, by a first and second lieutenant, as in the artillery and flank companies of the line.

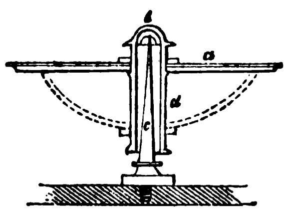
In the Austrian and Prussian armies, companies are stronger. In France, the strength of a company has varied very much. In former times, a company consisted of from 25, 30, 40, up to 200 men; in 1703, of 80 men; in 1808, they had 137 men; in 1814, 72 men; in 1823, 80 men. In 1820, a French battalion was composed of 8 companies, and a regiment of 3 battalions.

Comparative Anatomy is the science which investigates the anatomy of all animals with the view to compare them, to explain one by means of the others, and to classify the various kinds according to their anatomical structure. As comparison, and the formation and extension of genera and species, are the delight of the naturalist, comparative anatomy is one of the most interesting sciences. The want of an organ in certain classes of animals, or its existence under different modifications of form, structure, &c., cannot fail to suggest interesting conclusions concerning the office of the same part in the human subject. Thus comparative anatomy is of the highest importance to physiology. Haller observes, very justly, "Physiology has been more illustrated by comparative anatomy than by the dissection of the human body." Without comparative anatomy, the natural history of animals would always have remained in a backward state, more so even than mineralogy without the aid of chemistry. And it is to comparative anatomy that we owe, in a great measure, that more liberal view of nature which belongs to modern times and considers all nature, man included, as one unbroken whole. See Anatomy and Physiology. The comparative anatomy of the lower orders of the animal kingdom will be fully discussed in our division devoted to Natural History.

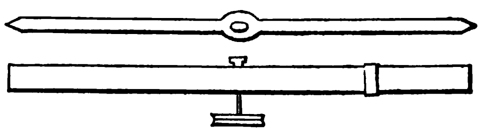
Compass, the Mariner's. The ancients, whose only guides on the trackless waters were the heavenly bodies, so often covered by clouds, could not venture far from shore. It is the compass which has enabled man to steer boldly across the deep. The inventor of this great instrument shares the fate of the authors of many of the noblest inventions. He cannot be precisely ascertained. Some call him Flavio Gioja; others, Giri, a native of Amalfi, in Naples, at the beginning of the 14th century; but there are proofs, that the use of the magnetic needle, in pointing out the north, was known at an earlier period in Europe, and that a contrivance similar to a compass went under the name of *marinette* in France, as early as the 12th century. The English first suspended the compass, so as to enable it to retain always a horizontal position, and the Dutch gave names to the divisions of the card. The earliest missionaries to China found the magnetic needle in use in that country.

The compass is composed essentially of a magnetic needle, suspended freely on a pivot, and containing a card marked with the 32 points of direction into which the horizon is divided, and which are thence called *points of the compass*. The needle always points to the north (excepting slight variations), and the direction which the ship is steering is therefore determined by a mere inspection of the card. This apparatus is enclosed in a brass box, with a glass covering, to allow the card to be seen without being disturbed by the wind. This again is freely suspended within a larger box, so as to prevent, as much as possible, the needle from being affected by the motion of the vessel. The whole is then placed in the binnacle, in sight of the man at the helm. On the inside of that part of the compass-box which is directly on a line with the vessel's bow, is a clear black stroke, called the *lubber-line*, which the steersman uses to keep his required course; that is, he must always keep the point of the card, which indicates his course, coinciding with the lubber-line. The compass here described is called the *steering compass*.

We have now to notice an improvement on the common compass. In high northern and southern latitudes, the opposite ends of the needle dip to so great an extent as to preclude the motion of the instrument. To prevent this inconvenience, a compass has lately been constructed which allows the needle *a*, to dip without destroying the equilibrium of the card to which it is attached. The curve described by the extemity of the needle, is shown by the dotted line *d*,



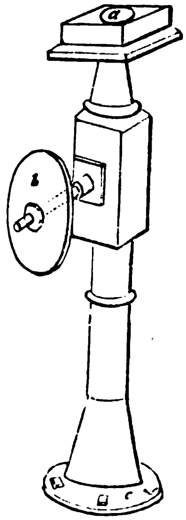
the card retaining its horizontal position, whilst the cap *b*, remains equally balanced on the point *c*.—To effect this, the compass bar, or needle, is suspended by a joint, consisting of two small pivots resting in a frame. The cause of the "dip," to which we have alluded, will be explained under the article Dipping Needle. In the compasses for use on land, a similar effect is produced by a small sliding weight placed on the needle.—Its situation is shown in the bar baneath.



The two views are intended to exhibit the proper relative proportion of the sides of the bar. If the bar was square, less effect would be produced with a given weight of metal than where this form is adopted.

In all vessels, and especially in those which have large masses of iron on board, the effect of the metal tends most materially to impair the accuracy of the compass, and, in some cases, to cause the loss of vessels at sea; and we shall now briefly notice Mr. Barlow's admirable discovery of a method of counteracting the local attraction of vessels. For this discovery, Mr. Barlow received the highest reward, viz. that of £500, given by the Board of Longitude. The instrument, as constructed by Mr. Barlow, is thus described: The centre of a small circular plate

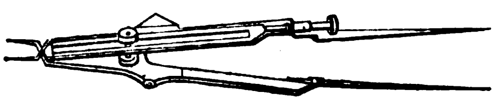
of iron, shown at *b* is placed in the line of the attraction of the ship's iron, and at a proper distance behind and below the pivot of the compass-needle, *a*; the position of this line having been previously ascertained, an operation now rendered easy by the tables for this purpose prepared by Mr. Barlow, and given with the instrumemt. When this is done, the needle will remain in operation in the polar regions, and direct itself in the true magnetic meridian, in whatever part of the world the ship may be. This effect of Mr. Barlow's invention has been established by experiments, between the 61° of south latitude, and the 81° of north latitude, by the accurate observations of Lieutenant Foster, and other naval officers.



With respect to the plate itself, it has hitherto been made double, viz. of two plates screwed together, in such a manner as to combine any strong irregular power of the one with a like weak point in the other; by which means a more uniform attraction is obtained. The plates may vary from 12 to 16 inches in diameter, according to the power of the vessel. They have a hole in their centre, through which is passed a brass socket, with a broad head, and with an exterior screw or nut, by which the two plates and an interposed piece of wood of the same size are compressed strongly together, the board being intended to increase the thickness, without adding much to the weight; and it is found that the two plates thus separated are more powerful than when in contact.

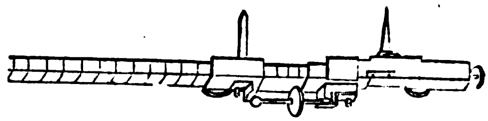
Compasses, or Pair of Compasses; a mathematical instrument, used for the describing of circles, measuring lines, &c. The common compasses consist of two branches, or legs of iron, brass, or other metal, pointed at bottom, and joined by a rivet, whereon they move as on a centre. We have compasses of various kinds and contrivances, accommodated to the various uses for which they are intended.

The only two forms which require a particular notice are the *proportional* and *beam* compasses. The first of these is represented beneath.



They consist of two limbs jointed in some point intermediate between either extremity. If in the centre, then the two extreme ends will describe circles of the same diameter; but if at one-fourth from one end, then a drawing may be reduced to one-third of its original dimensions, or *vice versá*. We exhibit an instrument thus constructed in the figure, but it possesses a species of delicate adjustment in the screw passing parallel to the upper limb, which enables the artist to make minute alterations in the general proportions of the figure. This he may effect by turning the screw and slightly changing the comparative length of the limbs. It may be proper to add, that the power of the instrument is considerably increased by cutting a groove in both limbs.

The beam compass consists of a bar with two points, one of which is fixed and the other moveable; and it will be found, on inspecting the annexed figure, that it is in its operation precisely similar to the common compass, but used in a horizontal position, which admits of a greater span or opening between the two points. The moveable point contains the pencil, and, in the best instruments, it is provided with an adjustment, as shown beneath.



Complement, Arithmetical. We observed, under the head of *subtraction*, in the article Arithmetic, that there was a mode of subtracting numbers by means of what is termed their arithmetical complement, which was attended in peculiar cases with considerable advantage; we will now explain it. Suppose that we have to subtract 614 from 5347, that is, to find the difference of 5347—614 This difference will not be effected by adding any number to it, provided that at the same time we subtract the same number from it. Let this number be 1000; then 5347—614 is the same as 5347 + (1000—614)—1000, or as 5347 + 386—1000. Now, instead of 386—1000, let us write $\bar{1}386$, incorporating 1000 with 386, but at the same time marking that it is subtracted, by putting the negative sign over it, so that 5347—$\bar{1}386$, has the same meaning as 5347 + 386—1000; $\bar{1}386$ is termed the arithmetical complement of 614. Similarly, the arithmetical complement of 1614 is $\bar{1}8386$, or of 252, $\bar{1}748$ or (1000—252)—1000, and that of 84, $\bar{1}16$ or (100—84)—100.

As we can perform such a subtraction as 614 from 1000 mentally, and obtain the result almost as soon as we could write down 614 itself, the advantage of employing these complements is considerable, where we have to find the result of several additions and subtractions, such as 5347—1614 + 18342—252 + 640—84; for by their use we get rid of every subtraction (with the exception of the very easy one of each 1000), and have only to perform an operation of addition. Taking the arithmetical complement of each of the numbers to which the negative sign is prefixed, we have

$$\begin{array}{r} 5347 \\ \bar{1}8386 \\ 18342 \\ \bar{1}748 \\ 640 \\ \bar{1}16 \\ \hline 22379 \end{array}$$

This method is much more expeditious than the ordinary one of taking separately the sum of the positive and of the negative terms, and then finding the difference of those sums.

Composite Order. See Architecture.

Compost, in *husbandry* and *gardening;* several sorts of soils, or kinds of earthy matter mixed together; or a mixture of earth and putrid animal substance; in fact, any artificial manure to assist vegetation.

Compound Numbers. By means of one unit, and its fractional parts, we are perfectly capable of expressing accurately the magnitude or *size* of any thing. If the only unit of distance we employed were a very small one—for instance, that known by the name of an *inch*—we should still be at no loss to denote the magnitude of any body, however great, by simply stating how many inches it contained. Instead of 1 *mile*, we should say 63360 inches; instead of 1 *yard*, 36 inches; and instead of 1 *foot*, 12 inches. Again, were our sole unit a great one—a mile for example—it would still suffice for all purposes connected with the measurement of length; 1 yard, 1 foot, and 1 inch would be just as precisely described by the $\frac{1}{1760}$th, $\frac{1}{5280}$th, and $\frac{1}{63360}$th of a mile respectively. But either of these methods would be attended with great inconvenience; in the one case it would be necessary to employ very large numbers, in the other our operations would be greatly encumbered with fractions. Hence it is customary in all civilized communities to have for each kind of thing a scale of units of different magnitudes or *denominations*, as pounds, shillings, pence, and farthings, for units of value, in England; miles, furlongs, poles, fathoms, yards, feet, and inches, for units of length; seconds, minutes, hours, days, &c., for units of time, and so on. A quantity expressed in units of different denominations is called a *compound number*.

It is evident that numbers may easily be changed from one denomination into any other of the same kind; the rules by which this change is effected are those of *Reduction*. Particular rules are also requisite for the addition, subtraction, multiplication, and division of compound numbers; these we shall now state.

To add compound numbers together, the common rule is: write them under one another, the numbers of the same denominations being all in the same column; add together those composing the column of the lowest denomination, and reduce it as far as practicable into the next higher; write under the column of the lowest denomination the part of its sum that remains of that denomination after the operation of reduction has been performed, and carry the other part to the next column; proceed through all the other columns in the same manner.

For example, the sum of 1*l.* 16*s.* 9*d.*, and 4*l.* 7*s.* 6*d.* must evidently be 1*l.* + 4*l.* 16*s.* + 7*s.* and 9*d.* + 6*d.*, or 5*l.* 23*s.* 15*d.*; but 15*d.* is equal to 1*s.* 3*d.*, and 23*s.* is equal to 1*l.* 3*s.*; therefore the sum becomes 5*l.* + 1*l.* 3*s.* + 1*s.* and 3*d.*, or 6*l.* 4*s.* 3*d.*

The rule for the subtraction of one compound number from another is this: write the number to be subtracted under the other, as in addition. When a number of any denomination in the upper number is less than the corresponding one in the lower, add to it as many units of that denomination as will make one unit of the next higher denomination, taking care at the same time always to increase the number of the next higher denomination in the lower number, by unity; then subtract the number of each denomination in the lower number from the number of the corresponding denomination in the upper.

Let us take for an example, to find the difference between 7*l.* 7*s.* 3*d.* and 4*l.* 18*s.* 6*d.* Here, as the number of the denomination of pence in the minuend (the upper number of the rule) is less than the number of the same denomination in the subtrahend (or lower number of the rule), we add to it as many units of that denomination (which is that of pence), as are equal to one unit of the next higher denomination (or that of shillings), namely 12; at the same time adding to the number of the next higher denomination in the subtrahend 1*s.*, which is equivalent to the 12*d.* we have given to the minuend. The pence number of the minuend thus becomes 15, and greater than the pence number of the subtrahend; and the shillings' number of this latter, 18, becomes by the addition of the 1*s.*, 19; this again being greater than 7, the shillings' number of the minuend, we increase this smaller one by 20—the number of units of the denomination of shillings necessary to make one unit of the next higher denomination, or that of pounds, taking care also to add one of these equivalent units to the 4*l.* of the subtrahend, thus to make it 5*l.* The difference required will then be 7*l.* − 5*l.* 27*s.* — 19*s.* 15*d.* — 6*d.*; or 2*l.* 8*s.* 9*d.*

To multiply a compound by a simple number, the ordinary rule is this:—multiply the number of every denomination in it by the simple number, and reduce each result to the highest denomination to which it is susceptible of reduction. There is, however, a much better way of performing this operation by means of the rules of *Practice*.

To divide a compound number by a simple number: Divide the number of the highest denomination by the divisor, and write the whole part of the quotient as the number of that denomination in the general required quotient; reduce the remainder, if any, to the next lower denomination, and adding it to the number of that denomination in the dividend, proceed as before, continuing this mode of operation till the number of every denomination has been divided; the several partial quotients obtained, form the numbers of the different denominations of the general quotient.

It is unnecessary to say any thing on the last two rules, as, together with the first two we have already spoken of, they are founded on the same principles as the similar operation, or simple numbers, which we have fully developed in the article **Arithmetic**. The multiplication and division of one compound number by another, will come more properly under the head of **Practice**.

Compressibility; the quality of bodies of being reducible, by sufficient power, to a narrower space, in consequence of their porosity, without diminishing their quantity of matter. All bodies are probably compressible, though the liquids, in particular, offer an almost invincible resistance to compression. Those bodies which occupy their former space when the pressure is removed, are called *elastic*.

Compression Machines; instruments for compressing or condensing elastic fluids. Such, for instance, is an air-pump with cocks, by which the air can be condensed in tight vessels. For the compression of liquids a very ingenious experimentor has constructed a metallic cylinder of 21 inches $5\frac{10}{12}$ lines high, and $3\frac{1}{2}$ inches $7\frac{1}{2}$ lines in diameter, 1 inch $2\frac{1}{2}$ lines thick. This cylinder is filled with water, and an iron piston, covered with leather, and exactly fitting the bore, is pressed into it. For this pressure, a screw was first used; but, in order to produce a better application of the power, a lever was afterwards employed to force down the piston. A mark on the piston shows, by its distance from a little ledge across the cylinder, how far the piston

has been forced down, and, when the force subsides, how far it has been driven up. See CONDENSATION.

CONCAVE; hollow; the reverse of convex.

CONCAVE LENS; an epithet for glasses ground hollow on the inside, so as to refract the rays of light.

CONCAVE MIRRORS. See OPTICS.

CONCENTRATION, in *chemistry;* the act of increasing the strength of fluids, by volatilizing part of their water.

CONCENTRIC; an epithet for figures having one common centre.

CONCERT; a musical performance, in which any number of practical musicians, either vocal or instrumental, or both, unite in the exercise of their respective talents. The concerts of the ancient Greeks were executed only in the unison or octave.

CONCERTO; a kind of musical composition, which is an imitation of the solo song with accompaniments—in short, an imitation of the *aria*. In the concerto, one chief instrument is distinguished, and leads the rest. In the case of such concertos, the performance is called after this instrument, or it is called, in general, *concerto di camera*. The term *double concerto* is used if there are two chief instruments.

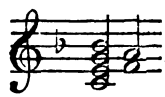
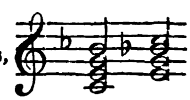
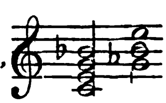
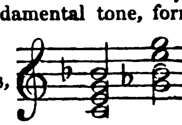
Concerto Grosso is an expression applied to the great or grand chorus of the concert, or to those places of the concert in which the *ripienos* and every auxiliary instrument are brought into action, for the sake of contrast and to increase the effect.

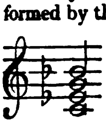
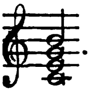
Concerto Spirituale was a concert at Paris, performed in the religious seasons, when the theatres were closed. The pieces performed, however, were not always of a spiritual kind. It was introduced in 1725, by Anne Danican, called *Philidor*.

CONCHA AURIS, in *anatomy;* the large hollow of the external ear.

CONCORD; an expression used in music. It denotes an association of sounds, founded on the natural relations of simultaneous tones. Upon this association depends all harmony; in fact, every proper chord is of itself harmony; hence, the expression *harmony of the dominant*. In its proper acceptation, harmony is the result of connected tones in consecutive chords.

With regard to their simultaneous expression, however, tones differ in their relations. Some, by the mere act of being sounded together, convey to the ear a sense of pleasure. They harmonize in themselves, and are therefore termed *consonant chords*, or *concords*. Take, for example, one tone as the fundamental tone; then, to form a concord, all the other tones must harmonize with it and with each other. The idea of a chord has no reference to the number of consonant tones of which it is formed. The most simple and least perfect concord is made by the combination of two tones, and is formed by connecting the interval of the third with the fundamental tone. The most perfect consonant chord is the harmonic triachord, which is formed by the addition of another third, and constitutes the perfect fifth from the fundamental tone; it is usually termed the *dominant*.

From the character of the first third, or mediant, these combinations are either major or minor; thus, major C, E, G, or minor C, E flat, and G. The minor triachord is to be distinguished from the diminished triachord, which by some is called the *false* or *dissonant*, and is formed by two minor thirds, or by the fundamental tone and the minor third and minor fifth; thus C, E flat, G flat. There is also a redundant triachord, constituted by two major thirds. By the transposition of the tones composing these triachords into higher or lower octaves (changing the positions or inverting the intervals), all other consonant chords are formed. It is usual to fix the designation of chords by counting the intervals ascending. Thus arises, first, the chord of the sixth (hexachord), in which the fundamental tone is placed an octave higher, so that the third becomes a fundamental tone; the fifth is then the third, and the transposed fundamental becomes the sixth; thus, E, G, C, designated by the figure 6. Second; the chord of the fourth and sixth, where the fundamental tone and its third are both placed in a higher octave, so that the fifth becomes the fundamental, the original fundamental is changed to the fourth, and the transposed third becomes the sixth. Hence the name, from the characteristic intervals and the notation, thus, $\frac{6}{4}$. The dissonant chords are first obtained by adding to the triad another third, which, consequently, stands in the relation of a seventh to the fundamental, and produces a quadrichord. The seventh is the dissonant interval, and, to relieve the ear, requires to be resolved. The chord of the seventh is formed of the fundamental, the third, the fifth, and the seventh. The first, and most usual, is constituted by the major triad with the minor seventh; thus C, E, G, B flat. It is called the *principal*, sometimes the *essential chord of the seventh*, and is simply designated thus, 7. It rests upon the dominant of that key in which it is to be resolved; for the minor seventh resolves itself downwards, thus, , while the major dissonant ascends. Hence it may also be called the *dominant chord of the seventh*, or the *chord of the dominant seventh*. If we transpose the intervals of these chords, in the same manner as with the triachords, we form, first, the chord of the fifth and sixth (denoted by $\frac{6}{5}$), consisting of the minor third, the minor fifth and major sixth, thus, ; Second; the chord of the third and fourth $\left(\frac{4}{3}\right)$, in which the seventh and the fundamental tone of the essential chord of the seventh become the third and fourth, ; Third, by farther transposition, the chord of the second is formed, by which the seventh, with the fundamental tone, forms the interval of the second, thus, . The

other chords of the seventh, which Weber terms *by-chords of the seventh*, in opposition to *principal chords of the seventh*, are, the chord of the seventh, formed by the minor triachord and the minor seventh, ; again, by the diminished triachord, with the subsisting minor seventh of the chord of the seventh, ; finally, the chord of the seventh, with the major triachord and seventh major, . By the transposition of these by-chords of the seventh are formed the chords of the fifth and sixth, the third and fourth, and the chord of the second.

We have thus, as appears from this review, nine fundamental chords, viz. two simple accords, three triachords, and four chords of the seventh (the essential chord and the by-chords of the seventh). However complicated the harmony may be, it is reducible to these chords. There is yet a five-toned chord, the *quint-chord*, which is a union of simultaneous tones, and is formed by the addition of another third (major or minor) to the chord of the seventh, which consequently makes the ninth from the fundamental tone, and is termed the *chord of the ninth*. But if, from the adverse concurrence of the seconds, we omit the fundamental tone, as is usual in close harmony, and transpose the notes as above, we obtain thus the proper modifications of the quadrichord; for example, the enharmonic chord of C, E flat, G flat, A; C sharp, E, G, B. These concords, then, are capable of being presented in the most diversified forms—in immediate collision, or broken, so that the tones constituting them are heard in succession. Farther, the intervals may be confined to one octave, or distributed through distant and different octaves. This forms the ground-work and the distinction between close and dispersed harmony, according to the close or dispersed position of the chords. Farther, the application of the intervals composing the chords is governed by the variety of positions, inasmuch as the music may be adapted for two, three, four, five voices or parts. In the former, some intervals must be omitted; in the latter, doubled.

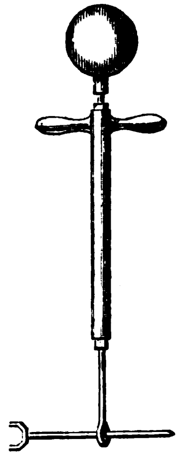
One of the first systems of chords was offered by Rameau, grounded on the ideas of D'Alembert, and afterwards elucidated in Marpurg's system, which much resembled Vogler's. It has been more recently elucidated by Türk. Another is by Tartini, which is given in Rosseau's *Dictionaire de la Musique*. The one deduces and explains the chords from fundamental keys (of the bass), the other from melody (the upper tones). Another very simple system of chords is that of Kirnberger, which is much followed by Godfrey Weber, in his treatise on thorough-bass.

From music, the idea of harmony is transferred to colours, and we may speak of the *harmony* of colours, as opposed to the harsh and dazzling contrast of them, which is avoided by a judicious middle tone of colouring.

Concretions, Morbid, in *animal economy;* hard substances that occasionally make their appearance in different parts of the body, as well in the solids as in those cavities destined to contain fluids: in the former case, they are denominated *concretions* or *ossifications;* in the latter, *calculi*. The concretions that make their appearance in the solids of the animal body are denominated *pineal* concretions, from their being found in that part of the brain called the *pineal gland;* or *salivary* concretions, as being discovered, occasionally, in the salivary glands; or *pancreatic* concretions, which are hard substances found in the pancreas; or *pulmonary* concretions, which have been sometimes coughed up by consumptive persons; or *hepatic* concretions, of which the liver is sometimes full. Concretions have also been found in the *prostate*. These have all been examined by chemists, and found to consist of phosphate of lime and other substances. Concretions have been discovered in the intestines and stomach of man, but more frequently in the bodies of other animals. Those found in the intestines of a horse were examined by Fourcroy, and found to consist of magnesia, phosphoric acid, ammonia, water, and animal matter.

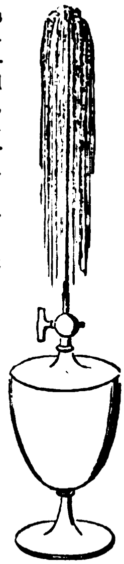
Condensation; the act of diminishing the bulk of a body.—Thus steam is condensed into water, by abstracting its heat, by which it is reduced in volume about two thousand times. By similar means gases are converted into fluids, and the latter into solids; but the most important species of condensation is that by mechanical means, which we may now proceed to describe.

It has already been shown, under the article Air, that the fluid atmosphere which surrounds our globe, is elastic, that its bulk may be reduced by mechanical means, and that this elastic force can, under certain circumstances, be employed as a substitute for gunpowder. The mode of accomplishing this, will be better understood by referring to the accompanying engraving.

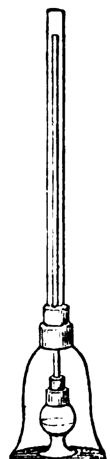


The syringe is furnished with a piston, made to fit air-tight, and provided with a strong metal ball, which may be attached or withdrawn at pleasure. If we now suppose the apparatus arranged as shown in the figure, and the piston depressed, it will be obvious that as much air as was previously contained within the tube, must be forced into the ball, where it is retained by a spring valve opening inwards. There is a very curious phenomenon which may be illustrated by this apparatus. What we call *dry air* would at least appear free from any considerable quantity of water. Such, however, is not the fact, as the warm air of a room in the summer season, will produce a complete shower of fine rain-like particles. To perform this experiment, the valve of the ball should be opened suddenly, when the air is in its highest state of condensation, and the water may then be received either on paper or a metal plate.

We may readily convert this species of condenser into a portable air-fountain, of which we give a diagram.—The syringe is, in this case, screwed on the upper end of the stop-cock, which is provided with a pipe descending beneath the surface of the water within. If we now suppose the air injected, and the syringe withdrawn, on opening the stop-cock, a jet of water will be impelled from the orifice, and in many cases raised ten or twenty feet in height. This pretty philosophical toy serves to illustrate the use of the air-condenser in a fire-eninge. It will be obvious that the power of those who are employed to work the engine, is imparted by a series of jerks, and yet the water passes from the ajutage in one continued flow. Now this practical advantage results from the use of a quantity of air, imprisoned within the condenser, which by its elasticity prevents the destruction of the pumps, and, at the same time equalises the motion of the stream of water.



We have now to examine the apparatus which is used for ascertaining with mathematical accuracy the precise amount of compression of any given volume of air. The apparatus consists of a tall glass tube closed at the top, and dipping in a vessel of mercury. This is placed beneath a receiver, firmly attached to a condensing plate; and on injecting air by the syringe, it presses on the surface of the mercury, driving it up the tube, If we find it ascend about half-way up the tube, then it is said to contain two atmospheres. The receiver, with tube, is shown in the diagram.



The common condensing-guage consists of a short tube, which is screwed to the receiver, and furnished with a graduated plate, by which the amount of compression is indicated.

CONDUCTOR. See ELECTRICITY and LIGHTNING.

CONDUIT, in *architecture;* a long, narrow passage between two walls, or under ground, for secret communication between various apartments, of which many are to be found in old buildings; also a canal of pipes, for the conveyance of water; a sort of subterraneous or concealed aqueduct. The construction of conduits requires science and care. The ancient Romans excelled in them, and formed the lower parts, whereon the water ran, with cement of such an excellent quality, that it has become as hard as the stone itself, which it was employed to join. There are conduits of Roman aqueducts still remaining, of from five to six feet in height, and three feet in width.—Conduits in modern times, are generally pipes of wood, lead, iron, or pottery, for conveying the water from the main spring or reservoirs to the different houses, and places where it is required. (See AQUEDUCT.)

CONE, in *geometry;* a solid figure, having a circle for its base, and its top terminated in a point or *vertex*. This definition, which is commonly given, is not, in mathematical strictness, correct; because no circle, however small, can become a mathematical point. But these deficiencies of mathematical strictness connected with constructive geometry, which is based on figures and diagrams, are avoided by analytical geometry, which operates without figures.

The word *cone* is derived from the Latin *conus.*—The figure might be called the *round pyramid,* according to the definition of a pyramid. Cones are either *perpendicular,* if the axis, that is, the line from the vertex to the centre of the base, stands perpendicularly on the base; or *oblique,* or *scalenous,* if the axis does not form a right angle with the base. If a cone is cut parallel with its base, the section, of course, is a *circle:* if, however, the section is made obliquely, that is, nearer to the base at one end than at the other, a curve is obtained, which is called an *ellipse*.

If the section be made parallel with the axis, perpendicularly from the vertex, or so as to make a greater angle with the base than is made by the side of the cone, the curve obtained is called a *hyperbola*. Thirdly, the section may be made parallel with one side of the cone, in which case the curve is called a *parabola*. These three lines, figures, and planes are called *conic sections,* and form one of the most important parts of mathematics, which is distinguished for elegance, demonstrating, with surprising simplicity, and beauty, and in the most harmonious connection, the different laws, according to which the Creator has made worlds to revolve, and the light to be received, and reflected, as well as the ball thrown into the air by the playful boy, to describe its line, until it falls again to the earth. Few branches of mathematics delight a youthful mind so much as conic sections; and the emotion which the pupil manifests, when they unfold to him the great laws of the universe, might be called natural piety.

Considering conic sections as opening the mind to the true grandeur and beauty of the mathematical world, whilst all the preceding study only teaches the alphabet of the science, we are of opinion that the study of them might be advantageously extended beyond the walls of colleges, into the higher seminaries for the education of females. The Greeks investigated the properties of the conic sections with admirable acuteness. A work on them is still extant, by Apollonius of Pergarnus. (See SECTIONS, CONIC.)

CONGELATION, *limit of perpetual.* Under COLD and TEMPERATURE our readers will find the phenomena of freezing and the effects of cold fully illustrated; but as all great mountain ranges have a point usually termed the "limit of perpetual congelation," it may be proper to notice the subject in a distinct form. We may suppose a traveller ascending Chimborazzo; he will, at the base, find a burnt and arid plain, and as he ascends the mountain, this will gradually give place to the trees and flowers of a more genial clime. Still higher, the Alpine, or severe mountain scenery will be observable, and after passing the lichens and more hardy plants, there will be a tolerably well defined climate of perpetual winter. Here, the snows are eternal as the mountains on which they fall, and seem distinctly to mark the barrier to which the labours of man and the progress of civilization shall be confined.

The limit of perpetual congelation in the Hymalaya Mountains, has been a matter of some controversy. A learned writer in the *Quarterly Review* has asserted, that this height is below 11,000 feet above the sea, and has maintained that the height of the range

itself, will be found much inferior to that of the Andes. Captain Webb, from numerous heights taken with the barometer, has drawn a very different conclusion.

"Near the temple of Milum (says Mr. Fraser, in his work on the great Himalaya Mountains), elevated 11,405 feet, there were large fields of good rye, and buck-wheat, and at an elevation of about 13,000 feet, he procured some plants of spikenard. On the 21st of June, Capt. Webb's camp was 11,680 feet above Calcutta. The surface was covered with rich vegetation as high as the knee, very extensive beds of strawberries in full flower, and plenty of currant-bushes in blossom all round, in a clear spot of rich black mould soil, surrounded by a noble forest of pine, oak, and rhododendron. And on the 22d of June, he reached the top of Pilgoenta-Churhaee, 12,642 feet above Calcutta.—There was not the smallest patch of snow near him, and the surface was covered with strawberry plants, butter-cups, dandelion, and a profusion of other flowers. The shoulders of the hill above him, about 450 feet more elevated, were covered with the same to the top, and about 500 feet below was a forest of pine, rhododendron, and birch." These facts led Captain Webb to infer that the inferior limit of perpetual congelation in the Himalaya Mountains, is beyond 13,500 feet at least above the level of Calcutta.

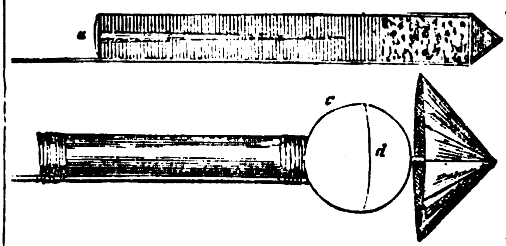
Congestion; a diseased state of the human structure, arising from an accumulation of the blood. The different parts of the human body do not always receive the same quantity of blood, but sometimes more, sometimes less. Thus, for instance, during digestion, it flows towards the stomach and the liver; during violent or long-continued speaking, singing, or running, it collects in the lungs and the heart; during close thinking, in the brain.

In general, the blood flows in greater quantities into any part in proportion to the action of that part; but, in a state of health, it flows off with as much rapidity as it collects. Sometimes, however, too much blood accumulates in an organ, and remains too long in it; and this injures the structure and the function of such an organ. Congestion may be caused by whatever, in general, accelerates the circulation of the blood, and causes it to tend to a particular part; thus, for instance, among the causes of congestion are the different periods of developement of the human body, each of which renders some particular organ unusually active; the crisis of disease; and, lastly, the accidental exertions of certain organs.

Under such circumstances, congestion is caused by an excited state of the arteries in general, and of some particular ones especially. Secondly, if the current of blood to one organ is checked, it accumulates in another. Hence, colds caught through exposure of the feet, also the suppression of the secretions, &c., so often cause congestion. Thirdly, the vessels which bring back the blood—the veins—are sometimes in a condition unfit to answer their destination; as for instance, if they are already too full, if their power to receive the blood and to propel it is lost or diminished, or if they are prevented from performing their function by external pressure, or by tumours. Hence congestions are divided into active and passive; those of the arteries and those of the veins. Where the blood accumulates, the part becomes red and hot, the pulse beats more violently, and the veins expand; the part swells, and a feeling of sickness, pain, pressure, &c. comes on. The functions of the part change; if the congestion is slight, they become more active. In higher degrees of congestion, and if it is continued for a long time, the functions are checked, weakened, and sometimes entirely destroyed.

Now, as every organ has its peculiar function, it follows, that the symptoms of congestion, resting on these grounds, must be very different, according to the different organs in which it takes place. During the congestion of blood in one organ, the other organs exhibit symptoms of want of blood, viz. coldness, paleness, diminution of size, and weakness. Congestion generally lasts but a short time; but if not early cured, and its return, which would otherwise be frequent, prevented, it is only the beginning of other diseases. Sometimes it terminates in bleeding, which is a remedy for it; sometimes it increases into inflammation; sometimes it becomes a chronic disease; that is, the blood accumulates for a long time, and expands the veins; the expansion becomes permanent, and the original excitement is succeeded by a state of torpidity and weakness, which is called *stagnatio*.

Congreve Rocket. This terrific weapon of destruction is, as its name implies, the invention of the late Colonel Congreve. Its two principal forms are represented in the engraving.



The simplest form of the rocket is delineated at *a*, *b*; the principle on which it ascends will easily be understood. If we suppose a tube filled with any inflammable material, ignited at an opening in the end, *a*, the disposition to expand will be equal in every direction: but as the resistance of the case is taken away at the opening, *a*, it will, of course, have a disposition to ascend in the opposite direction. The case, which is of copper or iron, and its destructive contents, are thus impelled with resistless force against the hostile ranks of an army, or the walls of a fortress.

The Congreve rocket has lately been enlisted in the cause of humanity, by the instantaneous destruction of large animals. We have been informed by a whale-fisher of much experience, that this species of missile is, in most cases, infinitely superior to the harpoon; and if, for argument sake, we admit the propriety of destroying those large and inoffensive "monsters of the deep," we should, at least in their deaths, remember mercy.

To the ball rocket, *c*, *d*, a parachute is attached, by which the rocket is partially supported in the air; and there are cases in which an instrument of this kind becomes exceedingly valuable for illuminating the neighbourhood of a fortress or out-work, during a night attack.

Conservatory; a musical school intended for the scientific cultivation of musical talents. They are sometimes public benevolent establishments, including hospitals, supported by rich private persons.—

The pupils have board, lodging, clothing, and instruction gratis. Besides these pupils, others are received who pay for their instruction; as, in Italy, the instruction in conservatories is preferred to private teaching. In Naples there were formerly three conservatories for boys; in Venice, four for girls. The most famous among the former was that of Santa Maria Loretto, established in 1537. Leo, Durante, Scarlatti, and Porpora were teachers at this school; and, among the great musicians educated there, it counted the distinguished names of Traetta, Piccini, Sacchini, Guglielmi, Anfossi, Paesiello, and others.

There were generally more than 200 pupils from eight to ten years of age in the conservatory of Loretto; in the others, about half this number. Pupils were received from eight to twenty years of age. The period during which they obliged themselves to stay in the establishment was generally eight years. If, however, it was discovered that a pupil had no talents for music, he was sent away. The conservatories in Venice were established in the same way. They were called *ospedale della pietà, delle mendicanti, delle incurabili,* and *ospedaletto di San Giovanni e Paolo.* Sacchini was for a long time the first instructor in the latter. The girls were obliged to conform to a very strict monastic kind of life, and used to remain in the establishment till they were married.

All instruments used in the public concerts were played here by girls and women. From these conservatories issued the great number of composers and male and female singers, who were met in every part of Europe. In Naples, the conservatories are reduced to a single establishment, which, in 1818, was removed to the former nunnery of St. Sebastiano, and received the name *real Collegio di Musica.* In Milan, the viceroy Eugene established a conservatory in 1808, the direction of which was given to Asioli.—It has 14 professors and 60 pupils.

In France, music was very little cultivated until Italian and German music was introduced by Piccini, Sacchini, Gluck, and others. The want of singers was now felt. The opera therefore established a musical school, and, in 1784, it was elevated into an *école royale de chant et de déclamation.* But it was not until the revolution that this institution acquired a high degree of importance. The want of musicians for fourteen armies was then felt, and in 1793, the Convention decreed an *institut national de musique.*

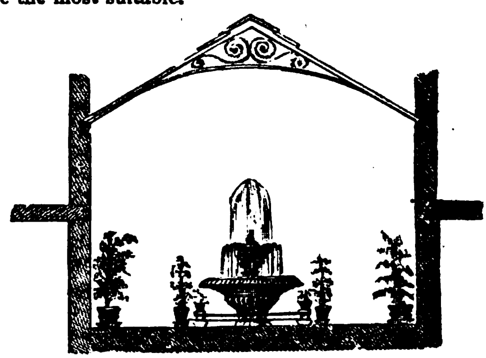
In 1795 it received its final organization, and the name of *conservatoire.* It was intended for both sexes. 600 pupils, from all the departments, were to be instructed there by 115 teachers. The expenses were fixed at 240,000 francs annually, but, in 1802, were limited to 100,000 francs, and, in consequence, the number of pupils and teachers was reduced.

The instruction was divided between music and theatrical declamation. The most distinguished musicians have been instructors in this institution; of whom we need only mention Gossec, Méhul, Garat, Choron, Cherubini, Grétry, Boïeldieu, Kreutzer, &c. Since its foundation, 2,000 musicians and singers of both sexes have been educated there. At the same time, the *conservatoire* is the central point of all amateurs of music. The public performances of the pupils are the most splendid concerts in Paris. The execution of symphonies, in particular, is unparalleled. For almost all branches of music, the *conservatoire* has published elementary works, or *methods,* as they are called, which are circulated, and adopted throughout Europe. Our own Royal Academy of Music is an establishment of a similar character.

Conservatoire Royal des Arts et Métiers, at Paris, is an establishment, which deserves the greatest praise, containing a collection of models of machines, of manufactures, &c., and having professors, who deliver lectures on mechanics, chemistry, and the processes used in manufacturing, to persons who wish to prepare themselves for pursuing mechanical arts, and the business of manufacturing in a scientific way. The foundation of this praiseworthy establishment was laid Oct. 10, 1794. After many important changes, is was finally organized by an ordnance, Nov. 25, 1819. There is now a valuable institution established in our metropolis for the exhibition of the useful arts. It is situate in Adelaide Street.

CONSERVATORY, in *gardening,* is a term generally applied, by gardeners, to plant-houses. They are sometimes placed in the pleasure ground, along with the other hot-houses, but more frequently attached to the mansion. The principles of their construction are in all respects the same as for the green-house, though, occasionally, a pit, or bed of earth is substituted for the stage, and a narrow border instead of surrounding flues. The power of admitting abundance of air, both by the sides and roof, is highly requisite, both for the green-house, and conservatory; but for the latter, it is desirable, in almost every case, that the roof, and even the glazed sides, should be removeable in summer.

When the construction of the conservatory does not admit of this, the plants in a few years become etiolated and naked below, and are no longer objects of beauty; but when the whole superstructure, excepting the north side, is removed during summer, the influence of the rains, winds, dews, and the direct rays of the sun, produces a bushiness of form, closeness of foliage, and a vividness of colour, not attainable by any other means. Therefore a conservatory, of any of the common forms, unless it be one devoted entirely to palms, ferns, *scitamineæ,* or other similarly growing plants, should always be so constructed as to admit of taking off the sashes of the roof and the front; and if it be a detatched structure in the flower-garden, a plan that would admit of the removal of every thing excepting the flues and the plants, would be the most suitable.

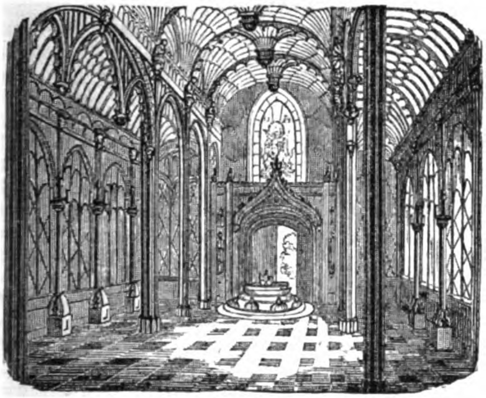


A conservatory well fitted for ornamental as well as practical purposes, is represented above, and it superadds the advantage of a fountain, which is at all times a considerable addition to edifices of this description,

Mr. Bailey, of Holborn, erected a very beautiful

domed conservatory, for the late Mrs. Beaumont, but, strange to relate, her son has since sold the entire edifice, one of the finest in the world, for little more than the worth of the materials.

One of the most beautiful Gothic conservatories yet constructed, was designed by the late Mr. Wyatt, for Carlton Palace, of which it formed a part. It was occasionally dismantled of its trees, and, in this state we present it to our readers, in the subjoined engraving.



Conserve, in *pharmacy*, &c.; a form of medicine or food, contrived to preserve the flowers, leaves, roots, peels, &c. of several simples, as near as possible to what they were when fresh gathered, to give them an agreeable taste Conserves are prepared from recent vegetable matter beaten together with sugar into an uniform mass. Vegetables, which soon lose their virtues by drying, may be preserved by this process, unimpaired, for a considerable length of time, the sugar preventing the natural decomposition, and moulding, which would otherwise take place. The sugar is first ground to a fine powder, and then mixed by long beating (not by solution) with the vegetable pulp or other material. No heat or other mode is employed, so that the vegetable matter remains, as nearly as possible, in the state in which it existed in the plant, at the moment of gathering.

Constellations are the groups into which astronomers have divided the fixed stars, and which have received names for the convenience of description and reference. The science of the constellations is called *astrognosy*.

The division of the stars into groups was begun in ancient times. It is plain that the union of several stars into a constellation, to which the name of some animal, person, or inanimate object is given, must be entirely arbitrary, since the several points (the stars) may be united in a hundred different ways, just as imagination directs; for instance, the best known of all the constellations, the Great Bear, or the Wain, might just as well be made to represent a great variety of other things. It is enough that astronomers know what is meant by a certain constellation, so as to understand each other. The division of the heavens into constellations is like the division of a classic into pages and paragraphs. The ancient divisions of the constellations have been retained by the moderns, with the addition of such as have been newly discovered. When and where the first constellations were formed, is not known.

It is very probable that some of the most remarkable collections of stars, such as Charles's Wain, the Pleiades, Orion, &c., were formed into constellations, and had names given them, in very early ages.—Some of them, by their different appearances, serve to mark out the different seasons of the year, and, on that account, were not only considered as a kind of directory for the commencement of ploughing, sowing, and other operations of husbandry, but were also regarded as having a great influence on the temperature of the air, and the fertility of the earth.—Hence, from their being signs, pointing out the times of the year when heat or cold, dryness or moisture, predominated, they were regarded as the causes of these states of the atmosphere. They were also imagined to have dominion over minerals, vegetables, and animals; over the complexions, constitutions, and even the dispositions of mankind. This opinion obtained credit the more easily, as the sun, moon, planets, and stars were believed to be of a divine nature, insomuch, that some persons conceived that they were inhabited by an inferior kind of deities, who governed their motions, and directed their influences; while others thought that they were animals, each of which had a living soul; and others again supposed that they were animated by a part of the substance of the Supreme Being. Each of these notions led mankind to pay them a sort of religious worship.

The Egyptians divided the heavens into several regions, which they called the stations, or mansions, of their gods. They worshipped the heavenly bodies, and more especially the sun and moon, which they called their *great gods*, denominating the sun *Osiris*, and the moon *Isis*. They also imagined that they found in various animals, some qualities corresponding to the motions, appearances, or influences of the sun, moon, and some of the stars; hence they were induced not only to use those animals in their hieroglyphic representations of their deities, but also to pay them divine honours, and denominate the constellations from them. The Greeks, who learned astronomy of the Egyptians, retained several of their figures, as the ram, the bull, the dog, &c., but accommodated almost all of them to the fabulous history of their gods and heroes, whom they placed among the stars. The Romans imitated them, and the poets of both nations have given us wild and romantic fables about the origin of the constellations, probably derived from the hieroglyphics of the Egyptians, and transmitted, with some alterations, from them to the Greeks. Many of the figures that occur among our present constellations were originally Egyptian.

The names which the Chinese and Japanese give to the groups of stars forming our constellations, are very different from those which we have given them. Some Arabians, too, though they received their astronomy from the Greeks, changed the names of the constellations, from a superstitious notion, that it was unlawful to draw any human figure. The zeal of some Christian philosophers has induced them to endeavour to drive the heathen deities and heroes from the skies. The venerable Bede gave the names of the twelve apostles to the twelve signs of the zodiac. Judas Schillerius, in 1627, completed the reformation, and gave Scripture names to all the constellations in the heavens. Weigelius, professor of mathematics in the university of Jena, made a new order of constellations, converting the firmament into a *cœlum heraldicum*, and introducing the arms of all

the princes of Europe among the constellations. The more intelligent astronomers, however, never approved of innovation, because it tended to introduce confusion into the science. The old constellations, therefore, are for the most part still retained.

Ptolemy enumerates in his *Almagest*, forty-eight constellations, which are still called the *Ptolemæan*. They are the following:—1. The twelve signs of the zodiac. 2. Twenty-one constellations found in the northern hemisphere—the Great Bear (*Ursa Major*, the Wain), the Little Bear (*Ursa Minor*), Perseus, the Dragon, Cepheus, Cassiopeia, Andromeda, Pegasus, Equus (Horse's Head), the Triangle, the Waggoner (*Auriga*), Boötes, the Northern Crown (*Corona Borealis*), Ophiuchus, the Serpent (*Serpentarius*), Hercules, the Arrow (*Sagitta*), the Lyre, the Swan, (*Cygnus*), the Dolphin, the Eagle (*Aquilla*). 3. Fifteen constellations in the southern hemisphere—Orion, the Whale (*Cetus*), Eridanus, the Hare (*Lepus*), the Great Dog (*Canis Major*), the Little Dog (*Canis Minor*), Hydra, the Cup (*Crater*), the Crow (*Corvus*), the Centaur, the Wolf (*Lupus*), the Altar (*Ara*), the Southern Fish (*Piscis Australis*), the Argo, the Southern Crown (*Corona Australis*). The poets of antiquity very ingeniously connected the most popular fables of mythology with the different constellations. Some of the constellations, however, have been changed: and even the ancients sometimes added new ones, such as the Hair of Berenice and the Antinous. Much still remained for modern astronomers to do. Hevelius introduced the twelve following new constellations:—the Shield of Sobiesky, the Squirrel, Camelopardalus, the Sextant, the Greyhounds, the Little Lion, the Lynx, the Fox and the Goose, the Lizard, the Little Triangle, Cerberus, and Mons Mænalus. When the Europeans began to navigate the southern hemisphere, many new stars of course appeared to them, which they never had seen in Europe. Thus twelve new constellations were added in the 16th century—the Indians, Crane, Phœnix, Fly, Southern Triangle, Bird of Paradise, Peacock, American Goose, Hydrus or Water-Snake, Sword-Fish, Flying-Fish, Chamæleon. Halley, in 1675, during his stay at St. Helena, added the Royal Oak (*Robur Carolinum*); and Lacaille, in 1750, during his stay at the Cape of Good Hope, added the fourteen following:—Officina Sculptoria, Fornax Chemica, Horologium, Reticulus, Rhomboidalis, Equuleus Pictorius, Cæla Praxitelis, Pyxis Nautica, Octans Hadleianus, Machina Pneumatica, Circinus (the Compass), Quadra Euclidis, Telescope, Microscope, and Table Mountain. To these have been added the Lapland Reindeer, the Hermit, the Brandenburg Sceptre, the Telescope of Herschel, the Shield of Poniatowsky, or Taurus Poniatowsky, the Honour of Frederick, and others, which cannot well be enumerated here, as their names have not been sanctioned by all nations. Thus the professors of Leipsic made of a part of Orion the constellation of Napoleon, but it did not come into use. The different stars of a constellation are marked by Greek letters. Several have also articular names. They are also divided according to their apparent magnitude; thus we speak of stars of the first, second, and third, up to the sixth magnitude. The last are the smallest visible to the naked eye. Orreries are frequently constructed which exhibit the pictorial appearance of these astronomical signs in the most beautiful manner. One of the best was made for Mr. Bartley, and those who were fortunate enough to hear the highly poetical illustrations introduced by that clever dramatic performer, must regret that it was combined with so little of practical science.

In the above sketch, we give a representation of the constellation. It is one of a series which very beautifully illustrates the clusters of stars; their situation being indicated by holes, pierced by angular punches regulated to the size of the star. Behind the drawing is placed a piece of tissue paper, which gives an even tint to the whole.

Constitution, in *medicine*; the general condition of the body, as evinced by the peculiarities in the performance of its functions: such are the peculiar predisposition to certain diseases, or liability of particular organs to disease, the varieties in digestion, in muscular power and motion, in sleep, in the appetite, &c. Some marked peculiarities of constitution are observed to be accompained with certain external characters, such as a particular colour and texture of the skin, and of the hair, and also with a peculiarity of form and disposition of mind; all of which have been observed from the earliest time, and divided into classes, and which received names, during the prevalence of the humoral pathology, that they still retain.

Consumption, in *medicine*. See Atrophy.

Contagion. This word properly imports the application of any poisonous matter to the body through the medium of touch. It is applied to the action of those very subtile particles arising from putrid substances, or from persons labouring under certain diseases, which communicate the diseases to others; as the contagion of putrid fever, the effluvia of dead animal or vegetable substances, the *miasmata* of bogs and fens, the *virus* of small-pox, *lues venerea*, &c., &c.

The principal diseases excited by poisonous *miasmata* are, intermittent, remittent and yellow fevers, dysentery and typhus. The last is generated in the human body itself, and is sometimes called the *typhoid fomes*. Some *miasmata* are produced from moist vegetable matter, in some unknown state of decomposition. The contagious *virus* of the plague, small-pox,

measles, chin-cough, *cynanche maligna*, and scarlet fever, as well as of typhus and the gaol fever, operates to a much more limited distance through the medium of the atmosphere than the marsh *miasmata*. Contact of a diseased person is said to be necessary for the communication of plague; and approach within two or three yards of him for that of typhus.

The Walcheren *miasmata* extended their pestilential influence to vessels riding at anchor, fully a quarter of a mile from the shore. The chemical nature of all these poisonous effluvia is little understood. They undoubtedly consist, however, of hydrogen united with sulphur, phosphorus, carbon, and azote, in unknown proportions and unknown states of combination. The proper neutralizers or destroyers of these gasiform poisons are, nitric acid vapour, muriatic acid gas and chlorine. The two last are the most efficacious, but are best used in situations from which the patients can be removed at the time of the application. Nitric acid vapour may, however, be diffused in the apartments of the sick without much inconvenience. Bed-clothes, particularly blankets, can retain the contagious matter, in an active state, for almost any length of time. Hence they ought to be fumigated with peculiar care. The vapour of burning sulphur or sulphurous acid is used in the East against the plague. It is much inferior in power to those already named. There does not appear to be any distinction commonly made between contagious and infectious diseases.

The infection communicated by diseased persons is usually so communicated by the product of the disease itself; for instance, by the matter of the small-pox; and therefore many of these diseases are infectious only when they have already produced such matter, but not in their earlier periods. In many of them, contact with the diseased person is necessary for infection, as is the case with the itch, syphilis, canine madness; in other contagious diseases, even the air may convey the infection, as in the scarlet fever, the measles, the contagious typhus, &c. In this consists the whole difference between the fixed and volatile contagions.

A real infection requires always a certain susceptibility of the healthy individual; and many infectious maladies destroy, forever, this susceptibility of the same contagion in the individual, and, accordingly, attack a person only once, as the small-pox, measles, &c. Other contagious diseases do not produce this effect, and may, therefore, repeatedly attack the same person, as typhus, itch, syphilis, and others. Sometimes one contagious disease destroys the susceptibility for another, as the cow-pock for the small-pox. In general, those parts of the body which are covered with the most delicate skin, are most susceptible of contagion; and still more so are wounded parts, deprived of the epidermis. Against those contagious diseases which are infectious through the medium of the air, precautions may be taken by keeping at the greatest possible distance from the sick, by cleanliness and fearlessness; but most completely by the vigilance of the health-officers, by fumigations according to the prescriptions of Guyton-Morveau, and more especially by the wonderful disinfectant powers of the chlorides of lime and soda. We can more easily secure ourselves against such contagious diseases as are infectious only in case of contact, by means of cleanliness, caution in the use of vessels for eating and drinking, of tobacco-pipes, of wind-instruments, beds, and clothes. No general preservative against contagious diseases is known, though many are offered for sale by quacks. The examination of the persons intended for nurses of infants is very necessary, as thousands of children may be infected by contact with them, and the cause of the disorder remain unknown.

Contraction, in *physics*; the diminishing the extent or dimensions of a body, or the causing its parts to approach nearer to each other, in which sense it stands opposed to dilatation or expansion. Water, and all aqueous fluids are gradually contracted by a diminution of temperature, until they arrive at a certain point, which is about 8° above the freezing point; but below that point they begin to expand, and continue to do so according as the temperature is lowered. Similar effects have been observed with regard to some metals. Speaking of contraction, a remarkable phenomenon, of considerable importance in manufactures, presents itself to our notice. It is the hardness which certain bodies acquire in consequence of a sudden contraction, and this is particularly the case with glass and some of the metals. Thus glass vessels, suddenly cooled after having been formed, are so very brittle, that they hardly bear to be touched with any hard body. The cause of this effect is thus explained by Dr. Young:—"When glass in fusion is very suddenly cooled, its external parts become solid first, and determine the magnitude of the whole piece, while it still remains fluid within. The internal part, as it cools, is disposed to contract still farther, but its contraction is prevented by the resistance of the external parts, which form an arch or vault round it, so that the whole is left in a state of constraint; and as soon as the equilibrium is disturbed in any one part, the whole aggregate is destroyed." Hence it becomes necessary to anneal all glass, by placing it in an oven, where it is left to cool slowly; for, without this precaution, a very slight cause would destroy it. The Bologna jars, sometimes called proofs, are small thick vessels made for the purpose of exhibiting this effect; they are usually destroyed by the impulse of a small and sharp body; for instance, a single grain of sand, dropped into them, and a small body appears to be more effectual than a large one; perhaps because the larger one is more liable to strike the glass with an obtuse part of its surface.

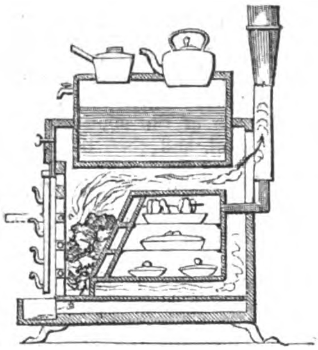
Contravallation; a line formed in the same manner as the line of circumvallation, to defend the besiegers against the enterprises of the garrison, so that the troops carrying on the siege lie between the lines of circumvallation and contravallation. As the line of circumvallation must be out of the reach of cannon shot from the place besieged, its circumference is necessarily so great as to render both its erection and its defence difficult. It is, therefore, seldom resorted to, and a corps of observation is generally preferred.

Converging Rays, in *optics*, those rays that, issuing from diverse points of an object, incline towards one another, till, at last, they meet and cross, and then become diverging rays.

Converging Series, in *mathematics*; series whose terms decrease the farther they proceed.

Converse, in *mathematics*. One proposition is called the converse of another, when, after a con-

under the name of portable kitchens, one of which is represented in the engraving beneath.



Our engraving shows the section of a stove invented by Mr. Williams, furnished with a grate, at the back of which there is an air passage, forming one side of the oven. Flues pass under and over the oven, and lead to the chimney. The boiler is at top, and there are falling bars in front of the grate, and there is a sliding plate to be occasionally lowered to act as a blower.

The first feature of novelty proposed is, the air-channel, which is supplied by an aperture with a slider opening from the outside near the bottom. The atmospheric air thus admitted, passes along the lower compartment, and becomes heated, then upwards into the second; returning again along that channel, it then rises into the third, and proceeds from thence through the upper part of the oven, and escapes by a small pipe into the chimney. The advantage of this air-channel is, that the fire of the grate will not be allowed to come in immediate contact with the oven, and also, that in passing through the top of the oven, it will cause the meat in that compartment to be roasted, instead of baked.

The second feature is the introduction of two sliders or dampers into the flues; and when it is required to throw the greatest heat into the boiler then the damper of the lower flue is closed, and the flame and smoke passed through the upper flue; but when, on the contrary, the heat of the oven is to be increased, the upper damper is closed, and the flame, smoke, and other vapour passed through the flue under and behind the oven. Apertures are made in the upper part of the boiler for introducing the bottom of a tea-kettle or saucepan, which are to be made to boil by the heat of the steam.

The third feature is two falling bars in front of the grate, which being let down, as shown by dots, form a ledge to set any vessel upon for stewing, &c. When it is required to increase the strength of the fire, the plate is slidden down over the upper part of the grate, which then acts as a blower.

Copaiba, or balsam of copaiba; a liquid resinous juice, issuing from incisions made in the trunk of a tree growing in the West Indies, of which there is only one species.

The juice is clear and transparent, of a whitish or pale yellowish colour, an agreeable smell, and a bitterish pungent taste. It is usually about the consistence of oil; when long kept, though retaining its transparency, it becomes nearly as thick as honey; and, unlike other resinous juices, does not acquire a solid state.

Genuine balsam of copaiba dissolves entirely in rectified spirits, especially if a little alkali be previously added to the liquor: the solution has a very fragrant smell. When distilled with water, it yields a large quantity of a limpid essential oil; and in a strong heat, without addition, an oil of a blue colour.

With respect to the medicinal properties of this balsam, it is said to be both corroborant and detergent. It strengthens the nervous system, tends to open the bowels, in large doses proves purgative, and promotes the secretion of urine. It has also been recommended, most injudiciously however, in dysentery, and in diseases of the chest or lungs. The dose of this medicine should not exceed from twenty to thirty drops. It may be conveniently taken when mixed with a thin syrup, or in the form of an emulsion, into which it may be reduced, by triturating it with a thick mucilage of gum arabic, till both ingredients are well incorporated, and then gradually adding a proper quantity of water.

Copal. This substance which deserves particular attention from its importance as a varnish, and which at first sight seems to belong to a distinct class from the resins, is obtained from the narrow-leaved or beach sumach, a tree which is a native of North America; but the best sort of copal is said to come from Spanish America, and to be the produce of different trees.

Copal is a beautiful white resinous substance, with a slight tint of brown. It is sometimes opaque, and sometimes almost perfectly transparent. When heated, it melts like other resins; but it differs from them in not being soluble in alcohol, or in oil of turpentine, without peculiar management. Neither does it dissolve in the fixed oils with the same ease as the other resins. It resembles gum animé a little in appearance, but is easily distinguished by the solubility of the latter in alcohol, and by its being brittle between the teeth, whereas animé softens in the mouth.

When copal is dissolved in any volatile liquid, and spread thin upon wood, metal, paper, &c., so that the volatile menstruum may evaporate, the copal remains quite transparent, and forms one of the most beautiful and perfect varnishes that can well be conceived. The varnish thus formed is called copal varnish, from the chief ingredient in it. Copal varnish used by the English japanners is made as follows. Four parts by weight of copal in powder are put into a glass matrass and melted. The liquid is kept boiling till the fumes, condensed upon the point of a tube thrust into the matrass, drop to the bottom of the liquid without occasioning any hissing noise as water does. This is a proof that all the water is dissipated, and the copal has been long enough melted. One part of boiling hot linseed oil (previously boiled in a retort without any litharge) is now poured into it, and well mixed. The matrass is then taken off the fire, and the liquid, while still hot, is mixed with about its own weight of oil of turpentine. The varnish thus made is transparent, but it has a tint of yellow, which the japanners endeavour to conceal by giving the white ground on which they apply it a shade of blue. It is with this varnish that the dial-plates of clocks are covered after having been painted white.

Copeck; a Russian copper coin, so called from the impression of St. George bearing a lance. A

hundred of them make one ruble. The value of the copper coin, compared with the assignation-ruble, varies in the different governments.

COPPER is of a red colour, with a tinge of yellow, having considerable lustre, but liable to tarnish and rust from exposure to the air. It is moderately hard, and has considerable ductility and malleability. Its specific gravity is 8.66. It has a sensible odour, especially when heated or rubbed, a styptic, unpleasant taste, and is peculiarly poisonous to animals. Copper melts at a full white heat, and, by slow cooling, may be crystallized. It suffers oxidation at a lower temperature from the action of the air, thin scales of oxide forming on its surface when it is heated to redness. At a higher heat, it burns with a green flame. Exposure to air and humidity, at the natural temperatures, converts it into a green rust, which is the oxide combined with a portion of carbonic acid.

There are two oxides of copper. The protoxide is of a red colour, and occurs native, in the form of octoedral crystals, in the mines of Cornwall. It is also prepared artificially, by mixing 64 parts of metallic copper, in a state of fine division, with 80 parts of the peroxide, and heating the mixture to redness in a close vessel; or by boiling a solution of the acetate of copper with sugar, when the peroxide is gradually deoxidized, and subsides as a red powder.

It consists of one atom, or proportional, of copper 64, and one of oxygen, 8, = 72. The sulphuric, muriatic, and probably several other acids, form with it salts, which, for the most part, are colourless. On exposure to the air, they attract oxygen, and are rapidly converted into per-salts. The peroxide of copper is also found native, and may be prepared artificially by calcining metallic copper, by precipitation from the per-salts of copper, by means of pure potash, or by heating the nitrate of copper to redness. It is composed of one atom of copper 64, and two of oxygen 16, = 80. It varies in colour from a dark-brown to a bluish-black, is insoluble in water, and does not affect the vegetable blue colours. It undergoes no change by heat alone, but is readily reduced to the metallic state by heat and combustible matter. It combines with nearly all the acids, and most of its salts have a green or blue tint. It is soluble, likewise, in ammonia, forming with it a deep blue solution—a property by which the peroxide of copper is distinguishable from all other substances.

Metallic copper is oxidated and dissolved by the greater number of the acids, and forms with them, in general, soluble and crystallizable salts. Sulphuric acid, either concentrated or diluted, oxidates it, and combines with the peroxide, especially when assisted by heat.

The solution is of a blue colour, and, when evaporated, affords crystals in the form of rhomboidal prisms. This salt is the *blue vitriol* of commerce, and is usually obtained, either by evaporation of the solution of it, formed by the infiltration of water through copper mines, or by exposure of sulphuret of copper to the action of air and humidity, until the sulphur is converted into sulphuric acid, and the metal is oxidated and combined with it. Nitric acid acts on copper with great energy, the metal attracting a portion of its oxygen, nitric oxide gas being disengaged, and the oxide combining with the remaining acid. The solution, when evaporated, affords prismatic crystals, of a deep green colour, deliquescent, and easily soluble in water. From the facility with which it parts with oxygen, it acts with energy on several substances. Thus it detonates when struck with phosphorus, and it burns several of the metals. If wrapped in tinfoil, the tin is oxidated with such rapidity as to be attended with inflammation.

Muriatic acid dissolves copper slowly when the air is admitted: if it is excluded, the action is very inconsiderable, unless heat is applied. The solution is of a fine green colour, and, by evaporation, slender prismatic crystals are obtained, which are deliquescent, and very soluble in water. The combinations of peroxide of copper with phosphoric, carbonic, and other acids, are effected by adding to a solution of nitrate, or sulphate of copper, a solution of a neutral salt, containing the acid with which the copper is designed to be combined. Copper is slowly oxidated by a number of weaker acids, as by some vegetable juices, when acted on by them with the admission of air. Acetic acid, or vinegar in particular, forms an important compound with the oxide of copper. To obtain it, copper plates are exposed to the fumes of vinegar. A crust is soon formed of a green colour, which is the *verdigris* of commerce.

All the salts of copper are decomposed by the alkalies and earths. Potash, soda, and the alkaline earths, throw down precipitates, which are of various shades of green or blue, according to the quantity of alkali added, the colour being green, if a small quantity is added, and becoming blue from a larger quantity. These precipitates are sub-salts, the alkali attracting the greater portion of the acid, but the oxide precipitated still retaining a portion of the acid combined with it.

The action of ammonia upon the salts of copper is more remarkable. It first abstracts a portion of the acid, and throws down a green or blue precipitate, which is a sub-salt; but, when added in larger quantity, it redissolves this precipitate, and forms a transparent solution, of a very deep-blue colour, which, when evaporated, affords fine blue crystals. A triple compound, used in medicine under the name of *ammoniuret of copper*, is prepared by triturating together two parts of sulphate of copper with one part of carbonate of ammonia, the mass becoming soft from the mutual action of the two salts, the carbonic acid being disengaged with effervescence, and the triple compound of sulphuric acid, oxide of copper, and ammonia, being obtained of a deep violet-blue colour.

Copper is precipitated in its metallic state, from its saline solutions, by zinc and iron; either of these metals attracting the oxygen which serves as the medium of its union with the acid of the solution. Its oxide is precipitated by albumen, and the precipitate is almost inert; hence the whites of eggs have been recommended as an antidote to the poisonous salts of copper. The best mode of detecting copper, when suspected to be present in mixed fluids, is by sulphuretted hydrogen. The sulphuret, after being collected, should be placed on a piece of porcelain, and digested in a few drops of nitric acid.

A sulphate of copper is formed, which, when evaporated to dryness, strikes the characteristic deep blue on the addition of a drop of ammonia. Copper and sulphur unite by fusion, the combination being attended with the evolution of heat and light. A bisulphuret of copper also exists in copper pyrites.

Copper combines with a great number of the metals by fusion. It communicates hardness to gold and silver, without much impairing their ductility, or debasing their colour, when in small proportion; hence it is employed in the standard alloys of these metals, that of gold containing one-twelfth, that of silver one-sixteenth, of the mass. With platina, it forms an alloy, ductile, and susceptible of a fine polish. With tin, it forms several valuable alloys, which are characterized by their sonorousness.

Bronze is an alloy of copper, with about 8 or 10 per cent. of tin, together with small quantities of other metals, which are not essential to the compound. Cannons are cast with an alloy of a similar kind, and the ancient bronze statues were of nearly the same composition.

Bell-metal is composed of 80 parts of copper and 20 of tin. The Indian gong, so much celebrated for the richness of its tones, contains copper and tin in this proportion. The proportion of tin in bell-metal varies, however, from one-third to one-fifth of the weight of the copper, according to the sound required, the size of the bell, and the impulse to be given. M. d'Arcet has discovered that bell-metal formed in the proportion of 78 parts of copper, united with 22 of tin, is, indeed, nearly as brittle as glass, when cast in a thin plate or gong; yet, if it be heated to a cherry red, and plunged into cold water, being held between two plates of iron, that the plate may not bend, it becomes malleable. Gongs, cymbals, and tamtams have been manufactured with this compound.

Brass. Copper and zinc unite in several proportions, forming alloys of great importance in the arts. The best brass consists of four parts of copper to one of zinc; and, when the latter is in greater proportion, compounds are formed called *tombac, Dutch gold*, and *pinchbeck*. An alloy called *Bath metal* is made by adding 9 pounds of zinc to 32 of brass; and an extremely pale, nearly white metal, used by the button-makers of Birmingham, under the name of *platina*, by adding 5 pounds of zinc to 8 of brass. The brothers Keller, who were very celebrated statue-founders, used an alloy, 10,000 parts of which contained 9140 of copper, 553 of zinc, 170 of tin, and 137 of lead. Their castings are very celebrated, and some are of very large size, as the equestrian statue of Louis XIV., cast at a single jet, by Balthazar Keller, in 1699, which is 21 feet high, and weighs 53,263 French pounds. These statues are usually called *bronze* statues, although made of brass. Brass was well known to the Romans, under the name of *orichalcum*, who took advantage of its resemblance to gold, in robbing the temples and other public places of that precious metal. Thus Julius Cæsar robbed the capitol of 3000 pounds weight of gold, and Vitellius despoiled the temples of their gifts and ornaments, and replaced them with this inferior compound.

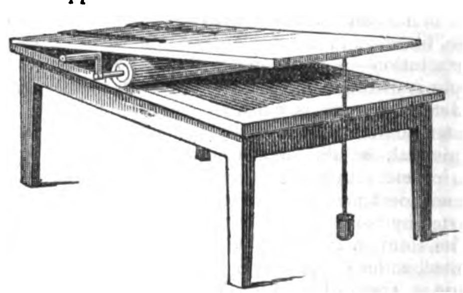
The art of *tinning* copper consists in covering that metal with a thin layer of tin, in order to protect its surface from oxydating. For this purpose, pieces of tin are placed upon a well-polished sheet of copper, which, if the process is skilfully conducted, adhere uniformly to its surface. The oxidation of the tin—a circumstance which would entirely prevent the success of the operation—is avoided by employing fragments of resin, or muriate of ammonia, and regulating the temperature with great care.

For an account of the ores of this metal, the reader is referred to the *Natural History* division of our work.

COPPERAS, or GREEN VITRIOL, is a mineral substance, formed by the decomposition of pyrites by the moisure of the atmosphere. Its colour is bright-green, and its taste very astringent. A solution of it in water, dropped on oak-bark, instantly produces a black spot. Copperas is occasionally found in grottoes, caverns, the galleries of mines, and other places. It is in much request with dyers, tanners, and the manufacturers of ink, and, for their use, is artificially prepared from pyrites. This mineral being moistened and exposed to the air, a crust is formed upon it, which is afterwards dissolved in water: from this the crystals of vitriol are obtained by evaporation. The principal use of vitriol is in dyeing woollen articles, hats, &c. black. It is the basis of ink, and is used in the manufacture of Prussian blue. If it be reduced to powder by the action of fire in a crucible, and mixed with powder of galls, it forms a dry portable ink.

We have, in the above short article, given the ordinary definition of the word *copperas*, though one more erroneous, both with regard to fact and theory, can hardly be conceived. In copperas there is *not one particle of copper*. It is, in truth, a *sulphate of iron*, and it may readily be formed by exposing iron to the action of sulphuric acid, which is but another name for the oil of vitriol of the shops. This is one out of many instances which might be adduced, of a false nomenclature which has been introduced by commercial men.

COPYING MACHINES. The most convenient mode of multiplying copies of a writing is by lithography, and this mode is much used by merchants and others in preparing circulars; also in the different departments of government. In Mr. Hawkins's polygraph, two or more pens are so connected as to execute, at once, two or more copies. Mr. Watts's copying machine is a press, in which moistened bibulous paper is forced into close contact with freshly written manuscript. The writing is, of course, reversed, but, the paper being thin, the characters can be read on the opposite side.



A simple copying machine, acting on the same principle as that of Mr. Watt, but much cheaper, is shown above. Its use must be obvious on the slightest inspection. Dr. Franklin used to cover writing, while moist, with fine powdered emery, and pass the sheet through a press in contact with a plate of pewter or copper, which thus became sufficiently marked to yield impressions, as in the common mode of copperplate printing.

CORDAGE; a general term for ropes, or rather small cords. They consist of twisted fibres, and at

an early period was, in all probability, only thongs of leather. These primitive ropes were retained by the Caledonians in the third century. The nations to the north of the Baltic had them in the ninth or tenth centuries; and the inhabitants of the western isles of Scotland make use of them at present; cutting the skin of a seal, or the raw and salted hide of a cow into long pieces, and fastening the plough to their horses with them, or even twisting them into strong ropes of twenty or thirty fathoms length.—But these, in the south of our island, and on the continent, were early superseded by the use of iron chains. The very maritime and commercial nation the Veneti, that were so intimately connected with the Belgæ of Britain, used iron chains for their cables in the days of Cæsar. But in the more distant and refined countries of the south, both thongs and these had given place to the use of vegetable threads, and the arts of combining them into strength. In this manner the Greeks appear to have used the common rushes of their country, and the Carthagenians the spartium or broom of Spain. And as all the cordage of the Romans was made of these materials at their last descent on our island, so the art of manufacturing them would be necessarily introduced with the Roman settlements among the Britons.—Under the direction of the Roman artists their thongs of leather would naturally be laid aside, and the *junci*, or rushes of the plains, worked up into cordage.

It is a curious circumstance, that a patent has lately been taken out for an invention which at once reminds us of the cordage of many of the uncultivated southern tribes. The object of this invention is to produce a rope, or sail cloth, which shall be impervious to water

The patentee proposes to employ, as the substance of his improved ropes or cordage, a vegetable production, called *silk grass*, which, when dried is to be beaten and heckled in the same manner that flax or hemp is usually prepared. In the process of preparing the grass, it is proposed to introduce a bituminous and gummy material, which is intended to saturate the fibres of the grass, for the purpose of preserving the ropes, cordage, or sail cloth, or any other fabric made from it, when exposed to the effects of damp.

This gummy material is to be compounded of the milk of a tree called the *ficus indica*, with *asphultum*, or *bitumen judaicum*, and *cocoa nut oil*. The proportions are to about twenty-five gallons of the milk, one gallon of the oil, and from one to twenty gallons of the bitumen, according to circumstances.

These substances when properly combined, which may be done over a slow fire, constitute a gummy material, into which the fibres of the grass may be dipped while heckling, and it also may be applied in twisting or spinning. It is likewise proposed that the workmen in twisting the strands of cord, shall dip their hands in the material, and work it well into the fibres and texture of the rope.

When this gummy material has become dry, it will resist water, and prevent the rotting effects of damp upon the fibres of the rope, cordage, sail cloth, or other articles manufactured from it.

Cordovan; a fine leather, which took its name from the city of Cordova, where it was manufactured in large quantities. Much is now made in the Barbary States.

Coriander. This seed has, when fresh, a very unpleasant smell. It is, on the contrary, very agreeable and aromatic when dry. It acts in the same manner as aniseed, &c., and enters into several medicinal compounds. Its infusion is occasionally employed as a sudorific. It is used, likewise, as a rective of certain purgatives.

Corinthian Order. See Architecture.

Cork is the external bark of a species of oak, which grows in Spain, Portugal, and other southern parts of Europe, and is distinguished by the fungous texture of its bark, and the leaves being evergreen, oblong, somewhat oval, downy underneath, and waved. The principal supply of cork is obtained from Catalonia in Spain. In the collecting of cork, it is customary to slit it with a knife at certain distances, in a perpendicular direction from the top of the trees to the bottom; and to make two incisions across, one near the top, and the other near the bottom of the trunk. For the purpose of stripping off the bark, a curved knife, with a handle at each end, is used. Sometimes it is stripped in pieces the whole length, and sometimes in shorter pieces, cross cuts being made at certain intervals.

In some instances, the perpendicular and transverse incisions are made, and the cork is left upon the trees, until, by the growth of the new bark beneath, it becomes sufficiently loose to be removed by the hand. After the pieces are detached, they are soaked in water, and, when nearly dry, are placed over a fire of coals, which blackens their external surface. By the latter operation, they are rendered smooth, and all the smaller blemishes are thereby concealed; the larger holes and cracks are filled up by the introduction of soot and dirt. They are next loaded with weights to make them even, and subsequently are dried and stacked or packed in bales for exportation.

The uses of cork were well known to the ancients, and were nearly the same to which it is applied by us. Its elasticity renders it peculiarly serviceable for the stopping of vessels of different kinds, and thus preventing either the liquids therein contained from running out, or the external air from passing in. The use of cork for stopping glass bottles is generally considered to have been introduced about the 15th century.

The practice of employing this substance for jackets to assist in swimming is very ancient; and it has been applied in various ways towards the preservation of life when endangered by shipwreck. The cork jacket, revived from an old German discovery by Mr. Dubourg, to preserve the lives of persons in danger of drowning, is constructed as follows:—Pieces of cork, about three inches long by two wide, and the usual thickness of the bark, are enclosed between two pieces of strong cloth or canvass, and formed like a jacket without sleeves; the pieces of cloth are sewed together round each piece of cork, to keep them in their proper situations; the lower part of the jacket, about the hips, is made like the same part of women's stays, to give freedom to the thighs in swimming; it is made sufficiently large to fit a stout man, and is secured to the body by two or three strong straps sewed far back on each side, and tied before; the strings are thus placed to enable any wearer to tighten it to his own convenience.

The floats of nets used for fishing are frequently made of cork. Pieces fastened together make buoys, which, by floating on the surface of the water, af-

ford directions for vessels in harbours, rivers, and other places. In some parts of Spain, it is customary to line the walls of houses with cork, which renders them warm, and prevents the admission of moisture. In the cutting of corks for use, the only tool employed is a very broad, thin, and sharp knife; and, as the cork tends very much to blunt this, it is sharpened on a board by one whet or stroke on each side, after every cut, and now and then upon a common whetstone. The corks for bottles are cut lengthwise of the bark, and consequently the pores lie across. Bungs, and corks of large size, are cut in a contrary direction: the pores in these are therefore downward—a circumstance which renders them much more defective in stopping out the air than the others. Cork-bark is almost entirely imported from Italy, Spain, and Portugal. In 1828, the imports were, from Italy, 81,035 cwt., Spain, 12,935 cwt., and Portugal, 5,029 cwt.

Cork is formed into soles for shoes; it is also ingeniously used, on account of its lightness, when an amputation of the human leg has been necessary, to supply the deficiency; the Spaniards line stone walls with it, which not only renders their houses very warm, but corrects the moisture of the air. The Egyptians made coffins of it, which being covered in the inside with a resinous composition, preserved their dead bodies. It is burnt to make that light black substance called Spanish black, from its first having been made in Spain.

Cork received into the stomach, in its crude state, is very deleterious: but after it has undergone certain processes, it is used in medicine. It contains a small quantity of very powerful acid, called suberic acid, which is different from all the other acids; but which easily unites with the alkalies and earths.

The business of cork-cutting, or the manufacturing of corks, though it is thought one of the most dirty, is not one of the least profitable; it is likewise easy in the acquirement. The cork, after being pressed into square pieces, is received by the cork-cutters, and if not sufficiently flat for their purpose, they "lay" it again over a fire in their "burning yard," turning the convex part to the flame; the heat, by twisting the edges of the bark, counteracts the natural bend, and compels it to receive a flat form. During this operation, a considerable degree of attention is paid to smoothing it, and particularly again to cover its defects. It is next cut into slips, narrow or wide, according to the intended cork, bung, or tap, for such are the names of the general divisions in this business. The use of the two former is well known, the latter is used for stopping the tap-holes of barrels, as the name implies. These slips are again cut into squares, of a length proportioned to the use they are intended for. This operation is performed by one man, from whom they are handed forward to several others. A farther division of corks takes place, of these different sorts, according to their lengths, and are denominated short, short long, and full long. The cork maker places himself before the table or plank, on which is fastened a board about three inches thick, four broad, and twelve long; immediately on a line with his left hand is a piece of wood rising about four inches from the board, and fixed about the middle of it, on which the cork is laid after being cut as above. This wood not only supports the cork, and is as a guide to the workman, but by its elevation above the board, gives room for the knife to cut a part of the cork in a smooth and circular manner.

Corn, in *rural economy;* the grains or seeds of plants, which are separated from the ear, and used chiefly for making bread.

There are several species of corn, such as wheat, rye, barley, oats, millet and rice, maize, or Indian corn, &c., each of which will be mentioned in its alphabetical order: we shall, therefore, in this place, not enter into any particulars relative to its culture, confining ourselves solely to such points as relate equally to the different species. We cannot but animadvert upon the injudicious practice of cutting corn in cold autumns, before it is perfectly ripe; as experience has proved, that if left standing, the ears will continue to fill, and become heavier even during the autumnal frosts. Were this latter method adopted, a much greater proportion of flour might be produced, and the grain would neither shrink nor shrivel, in barns or granaries; it might, at the same time, be prevented from rotting, on account of its immaturity, and the softness or moisture which are the necessary consequence.

Notwithstanding the great care and attention which the husbandman may bestow on the cultivation of corn, his expectations of a plentiful harvest are often frustrated by a variety of disorders and accidents, to which corn is peculiarly liable.

The first and most formidable is the smut, which is caused by vermin breeding in the grain, and thus destroying its substance. Their propagation, besides other causes, is evidently facilitated by laying on the soil too large a quantity of crude dung; which, becoming mouldy, promotes the generation of the smut animals.

Various experiments have been accordingly tried to eradicate this noxious distemper, with different degrees of success, a few of which we shall enumerate. In the greater part of the counties of Devon and Cornwall, on the evening before the wheat is intended to be sown, it is laid on the floor in a heap, on which is poured a solution of lime, slaked with boiling water, and reduced to the consistence of cream: both are then mixed, and left together till morning, by which time the wheat is dry and fit to be sown.

In other parts of the same counties the wheat is steeped either in fresh or salt water, for twelve, eighteen, or twenty-four hours, when it is put to to drain for an hour or two; after which, powdered lime is sifted over it, the whole being well mixed with a shovel: it is then thrown together in a heap, to dry previously to its being sown. Few farmers, however, soak it in lime, and a still smaller number of them substitute animal urine, soap-boilers' lye, &c. In several other counties there prevails a general practice of employing brine, strong enough to float an egg, to which powdered lime is added, till it acquires an unctuous consistence. This composition is mixed with the wheat, the evening before it is committed to the ground. In Yorkshire some farmers render the solution thicker, by the addition of lime, while others either sprinkle the wheat with it, or steep and wash the former, then sift lime over it, and mix them as before. Another method is, to put seventy gallons of water into a tub, at the bottom of which is a hole provided with a staff and tap-hose, as in brewing; to this is to be added half a hundred weight of limestone, and the whole well stirred for half an hour, when it is suffered to stand about

thirty hours. It should then be drawn off into another tub, and three pecks (forty-two pounds) of salt added, which, when dissolved, will make a strong pickle, fit for immediate use. But, if sea-water can be procured, half the quantity of salt will be sufficient. A basket of about two feet in diameter at the bottom, and twenty inches deep, should then be placed in the pickle, and the corn gradually immersed in small quantities, from one to two bushels, care being taken to skim off the light grains, which ought not to be sown, because many of them are infected with the smut. As soon as this operation is completed, the basket should be drawn up and drained for a few minutes over the liquor, when it may be repeated as often as the quantity of grain to be sown may require. This seed will be fit for the ground in twenty-four hours; but, where it is to be drilled, it should stand for forty-eight; and, if the driller meets with any difficulty in performing his work, it will be necessary to make the pickle more astringent, by adding lime. Seed thus prepared may be kept for five, six, seven, eight, or even ten days above ground, without any injury or inconvenience.

Corn is also liable to be grown, or sprouted, when it has partly begun to vegetate; for, if the whole of the grain were to bud, it would become unfit for being converted into bread. Hence it is very difficult to preserve sprouted corn, as the opening of the bud occasions it to heat, and the moisture it retains disposes it still more to undergo the process of fermentation. It is also more subject to be attacked by insects, on account of its being sweeter, more tender, and susceptible of heat, consequently more liable to receive their eggs. If left to itself, sprouted corn heats, ferments, and contracts an unpleasant smell and a bad colour; it also acquires a disagreeable sharp taste, which is communicated to the flour and bread; and, finally, grows mouldy and sour: in this state it is fit only for the manufacture of starch. Farther, it is ground with difficulty, clogs the millstones, chokes the bolting-cloths, and yields but little flour, which is soft and moist, and will not keep for any length of time, especially during warm weather.

We have entered thus largely into this subject, because, from the variableness of the climate of this country, considerable quantities of corn frequently become sprouted: we therefore extract, with satisfaction, the following interesting particulars, for remedying this serious evil, from an ingenious pamphlet published in France:—

Sprouted corn should by no means be stacked, but housed and threshed with the greatest expedition. Nor should it be put into a granary together with dry grain, as the latter will thus become moist. Care should also be taken to keep the place well aired; for, in the contrary case, even the latter cannot be preserved. As soon as sprouted corn is threshed, it should be spread upon the floor, and frequently turned, a door or window being left open to give vent to the steam. Sometimes it will be necessary to dry the corn in an oven, after the bread is removed, leaving the door half open, and turning the grain every ten minutes, to facilitate the evaporation of the moisture. When it is thus dried, it should be sifted, and not put into sacks or in heaps till it is properly cooled, as it will otherwise become mouldy.

Although some fastidious persons may object to the trouble occasioned by this mode of curing sprouted corn, yet, as eight or ten days' continual drying will preserve it for a whole year, and render both the bread and flour of a better quality, it surely merits the attention of every diligent husbandman, and will amply compensate his trouble and labour.

There is another disease that frequently attacks corn, which is usually termed burnt-grain. To these may be added what is called the spur, which affects both wheat and rye, but more especially the latter. The grains infested with it are thicker and longer than the sound ones; their outsides are either brown or black, and their surface rough. If spurred grain be opened, a white flour is perceivable in it, which is covered with another of a reddish or brown colour. The latter has some degree of consistence, but may be easily crumbled between the fingers. Naturalists are unable to ascertain, with precision, the cause of this distemper; but it is supposed to be occasioned by the bite or sting of an insect, that turns the corn into a kind of gall—a conjecture which is partly confirmed by the taste left on the tongue after eating such grain. The effects arising from the use of corn thus damaged, are said to be malignant fevers and gangrenes, in consequence of which the extremities of the body sometimes mortify, and spontaneously separate, without any pain or effusion of blood.

Among the various insects which prey upon corn, none is more destructive than the corn-butterfly, which is generated in a manner similar to that of the common butterflies. It settles on one grain, and after having totally consumed it, its existence is supposed to be prolonged by eating its own excrement. When it has attained its full growth, it is about one quarter of an inch in length, and half the thickness of the grain it has devoured. To exterminate this noxious insect, it has been recommended to prepare a very strong lye of wood-ashes, to which, when it becomes yellow, as much quick-lime should be added as will make it of a dusky white: while it is as hot as the hand can well bear it, the grosser part of the lime should be suffered to subside, and the lye poured off into a proper vessel; into which the corn is to be immersed by means of a basket, and quickly agitated, skimming off those grains which float on the surface. In the course of two or three minutes it may be taken out, and the basket, with its contents, suspended on two poles, to drain; after which it should be spread on the floor of a granary to dry, while a second basket undergoes a similar immersion. This simple process not only preserves the grain from rotting, but at the same time destroys all those insects that may have penetrated its substance.

With respect to the manner of preserving it, corn is very different from fruits; as, with proper care, it may be kept in granaries for several centuries. When it is designed to preserve the grain for a length of time, it should be well dried and cleaned before it is housed, care being taken to introduce air-holes on the top, and openings on the north and east of the granary. During the first six months, the corn should be carefully turned, once a fortnight at the least, to prevent it from heating; after which time it will be sufficient to turn it every month for about two years, when it will have exhaled all its igneous particles, and no apprehension need be entertained, unless from the air and adventitious moisture. Should it, nevertheless, heat from any unforeseen accident, so that there is apprehension of

its catching fire, such a misfortune may be easily prevented by making a hole in the middle, down to the floor, which will serve as a kind of chimney, or flue, for carrying off the heat. But, notwithstanding these precautions, it frequently happens that mites reduce the greater part of the grain to dust. This serious damage may be prevented by rubbing the adjacent places with fetid oils and herbs, such as garlic and dwarf-elder, the strong smell of which tends to expel them: besides, they may be exposed to the rays of the sun, which immediately destroys them. Among the numerous suggestions of foreign writers for preserving grain from the devastation of insects, we shall only mention those of smoking the store-houses with sulphur and tobacco (which, however, renders the corn unfit for vegetation); of covering the heaps of grain either with thin sail-cloth or old sheets, rolling them together when the vermin are settled on the surface, and exposing them to the voracious appetite of poultry in the farm-yard; of brushing them off the walls with hard brooms; of introducing ants, their greatest enemies, into the granary; of exposing dead lobsters; and, lastly, of ventilating the whole building, and frequently stirring the grain—remedies which, of all others, are perhaps the most efficacious methods of averting damage.

For the information of those dealers who avail themselves of arsenic, to destroy the rats and mice frequenting their corn-floors, we think it our duty to observe, that such a dangerous remedy ought never to be employed, as it has frequently produced the most fatal accidents, and as the excrements of the poisoned animals, where mixed with the grain, may likewise occasion disorders, the cause of which is not even suspected by physicians. Hence we advise those mercenary economists to substitute a remedy, which will be found equally effectual, and is perfectly safe: it merely consists in mixing two parts of pounded quick-lime, three parts of sugar, and placing at the side of it a separate shallow vessel, with water. The heating nature of this composition very speedily excites thirst, and induces those depredators to drink eagerly: in consequence of which the lime is slaked in their stomachs, and proves inevitably destructive.

When corn has been cleared of all impurities, in the manner above stated, it may be kept for a great number of years, nay, for ages, by depositing it in dry pits covered with strong planks: but the safer method is, to cover the heap with quick-lime, which should be gradually dissolved by sprinkling over it a small quantity of water. This causes the uppermost grains to sprout to the height of two or three inches, and incloses them with an incrustation, through which neither insects nor air can penetrate.

In order to ascertain the relative value of different species of grain, corn-dealers avail themselves chiefly of the combined criterion of weight and measure. In a commercial point of view, such a method is, doubtless, the most accurate; but, as it cannot be explained without entering into a very diffuse detail, accompanied with numerical tables, we shall communicate to our economical readers only a few practical directions, by an attention to which they may be sufficiently guided in the sale or purchase of corn in general.

1. Take a handful of grain from a heap, or sack, and compress it closely for a minute; then pass it from one hand to the other, and attentively examine its flavour, whether it possesses any peculiar smell different from that which is peculiar to the species; in which case you may conclude that it has been repeatedly exposed to moisture, and undergone a slight degree of fermentation. The flour obtained from such corn is deficient in measure, of an indifferent quality, and affords neither nourishing nor wholesome bread.

2. If, on pressure of the hand, the grains appear so solid and smooth that they in a manner glide through the fingers, without having any foreign smell or colour, in this case it may be pronounced perfectly dry, and in a good state of preservation.

3. Should, on the contrary, the corn feel rough, or if a number of grains, after compressing them by the dry hand, clog together and adhere to the fingers, it may be justly apprehended that such wheat, rye, &c. is damp, and possessed of all the bad properties before specified. (See AGRICULTURE and BREAD.)

CORN; a hardened portion of cuticle, produced by pressure; so called, because a piece can be picked out like a corn of barley. Corns are generally found on the outside of the toes, but sometimes between them, on the sides of the foot, or even on the ball. They gradually penetrate deeper into the parts, and sometimes occasion extreme pain, and, from the frequency of their occurrence, hold a prominent rank among the petty miseries of mankind, and frequently exert no small influence upon the temper of individuals.

No part of the human body, probably, has been injured so much by our injudicious mode of dress, as the feet, which have become, in general, deformed; so much so, that sculptors and painters can hardly ever copy this part from living subjects, but depend for a good foot almost solely on the remains of ancient art. To this general deformity of the foot belong the corns, produced by the absurd forms of our shoes and boots.

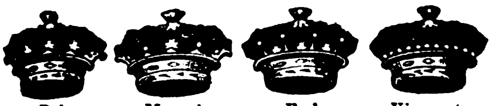
They appear, at first, as small dark points in the hardened skin, and, in this state, stimulants or escharotics, as nitrate of silver (lunar caustic), are recommended. The corn is to be wet, and rubbed with a pencil of the caustic every evening. It is well to have the skin previously softened. If the corn has attained a large size, removal by cutting or by ligature will be proper; if it hangs by a small neck, it is recommended to tie a silk thread round it, which is to be tightened every day, until the corn is completely removed. In all cases of cutting corns, very great precaution is to be observed. The feet ought always to be bathed previously. Mortification has, in many instances, resulted from the neglect of this precaution, and from cutting too deep. Another simple and generally very efficacious means, is the application of a thick adhesive plaster, in the centre of which a hole has been made for the reception of the projecting part. From time to time, a plaster must be added. Thus, the surrounding parts being pressed down, the corn is often expelled, and, at all events, is prevented from enlarging. Paring with files, rubbing with fish-skin, &c., have been likewise found effective. In large cities, as London, Paris, &c., people make a business of curing corns, and are called *Chiropodists*.

CORNET; a wind instrument, now but little known, having, for more than a century since, given place to the hautboy. There were three kinds of cornets,—the treble, the tenor, and the bass. The treble and tenor cornets were simple curvilineal tubes, about

three feet in length, gradually increasing in diameter from the mouth-piece towards the lower end. The bass cornet was a serpentine tube, four or five feet long, and increasing in diameter in the same manner.

CORNET, in military language, is the third officer in a company, in England and the United States.—He bears the colours of the troop. In the Prussian army, the name *cornet* is abolished.

CORONET; an inferior crown, belonging to the English nobility. The coronet of an English duke is adorned with strawberry leaves; that of a marquis has leaves, with pearls interposed; that of an earl raises the pearls above the leaves; that of a viscount is surrounded with pearls only; that of a baron has only four pearls. A series of coronets are represented beneath.



CORPORAL. This word is written in the same, or in a similar manner, in many languages, and, at first sight, would seem to be derived from *corps* (body); but it originates, in fact, from the French *caporal*, and the Italian *caporale*, which are derived from *capo*, the Italian form of the Latin *caput* (the head). The change of the first syllable, *ca*, into *cor*, is of much antiquity. Du Fresne uses the Low Latin term *corporalis*. From this author it appears, that *corporal* formerly signified a superior commander; but, like *captain*, and many other words, it has sunk in its dignity. A corporal is now a rank and file man, with superior pay to that of common soldiers, and with nominal rank under a sergeant. He has charge of one of the squads of the company, places and relieves sentinels, &c. Every company in the English service has three or four corporals. In armies in which privates may advance to the highest ranks, as in France, Prussia, &c., great care is taken in selecting corporals. In fact, they are officers of much importance, associating, as they do, with the privates, over whom, their superiority of rank gives them much influence. The feeling of military honour, good morals, and emulation in the discharge of duty, are, in a great degree, to be infused into the mass by means of the corporals.

A corporal of a man-of-war is an officer who has the charge of setting and relieving the watches and sentries, and who sees that the soldiers and sailors keep their arms neat and clean: he teaches them how to use their arms, and has a mate under him.

CORPUSCULAR PHILOSOPHY; that mode of philosophizing which endeavours to explain things, and to account for the phenomena of nature by the motion, figure, rest, position, &c. of the corpuscles, or the minute particles of matter.

Boyle reduces the principles of the corpuscular philosophy to the four following heads:

1. That there is but one universal kind of matter, which is an extended, impenetrable, and divisible substance, common to all bodies, and capable of all forms. On this head, Newton remarks thus: "All things considered, it appears probable to me, that God, in the beginning, created matter in solid, hard, impenetrable, moveable particles; of such sizes and figures, and with such other properties, as most conduced to the end for which he formed them; and that these primitive particles being solids, are incomparably harder than any of the sensible porous bodies compounded of them; even so hard as never to wear or break in pieces; no other power being able to divide what God made one in the first creation. While these corpuscles remain entire, they may compose bodies of one and the same nature and texture in all ages; but should they wear away, or break in pieces, the nature of things depending on them would be changed; water and earth composed of old worn particles, of fragments of particles, would not be of the same nature and texture now, with water, and earth composed of entire particles at the beginning. And therefore that nature may be lasting, the changes of corporeal things are to be placed only in the various separations, and new associations, of these permanent corpuscles."

2. That this matter, in order to form the vast variety of natural bodies, must have motion in some, or all its assignable parts; and that this motion was given to matter by God, the creator of all things; and has all manner of directions and tendencies. "These corpuscles, says Newton, have not only a vis inertiæ, accompanied with such passive laws of motion as naturally result from that force; but also are moved by certain active principles; such as that of gravity, and that which causes fermentation, and the cohesion of bodies."

3. That matter must also be actually divided into parts; and each of these primitive particles, fragments, or atoms of matter, must have its proper magnitude, figure, and shape.

4. That these differently sized and shaped particles have different orders, positions, situations, and postures, from whence all the variety of compound bodies arises. See ATOMICAL PHILOSOPHY.

CORPOSANT; a name given by the Italians to the electric flame which sometimes appears on the tops of the masts of vessels, and is also called *Castor and Pollux* and *St. Elmo's fire*.

CORPS; a word often used in military language, many of the terms of which are derived from the French, they having begun the organization of armies on the system which now prevails. The term is applied to various kinds of divisions of troops.—*Corps d'armée* is one of the largest divisions of an army—*Corps de garde;* a post occupied by a body of men on watch; also the body which occupies it.—*Corps de reserve;* a body of troops kept out of the action, with a view of being brought forward, if the troops previously engaged are beaten, or cannot follow up their victory, or are disorganized.—*Corps volant* (a flying body) is a body intended for rapid movements. It is always rather small.—*Corps de bataille* is the main body of an army, drawn up for battle between the wings.

CORPULENCE; the state of the human body, when loaded with an excessive quantity of flesh and fat. The flesh forms the muscular system; and, its extent being limited by the form of the particular muscular parts, its quantity can neither exceed nor fall below a certain bulk. The fat is much less limited, and the production and deposition of it is confined to no such definite form. The formation of the muscular fibres, or the change of blood into flesh, takes place in the capillary system, formed by the minutest portions of the arteries at their termination in the muscles. If blood is copiously furnished with nutritive matter, it is converted readily to muscular fibres

and fat. The secretion of fat depends, in a certain degree, on the state of the health.

Children and females have a larger proportion of it than adult men. It is promoted by rich diet, a good digestion, corporeal inactivity, tranquillity of mind, &c. There is, however, a certain diseased state of the system, which, independently of all these influences, will increase the production and deposition of fat. We see young people and men, even such as are intelligent, and continually engaged in active business, very corpulent.

The enormous corpulence of many men appears to bear no proportion to their food, and is evidently a disease, as many other secretions in the body; for example, the preparation and secretion of the bile, saliva, &c., are augmented by disease. Sandiford mentions an unborn child, in which he observed a monstrous mass of fat. Tulpius saw a boy five years old, who weighed 150 pounds. Bartholini makes mention of a girl, aged eleven years, who weighed above 200 pounds. In the *Philosophical Transactions*, mention is made of an Englishman, named Bright, who weighed 609 pounds. Daniel Lambert, of Leicester, was, probably, the heaviest man on record. He weighed 752 pounds. A Canadian, named Maillot, who exhibited himself at Boston, in 1829, weighed 619 pounds. Corpulency is often only the repletion of the cells of the cellular membrane with watery, gaseous, and vaporized matter, arising from a marked tendency to disease, and often the commencement of actual dropsy. Moderate corpulence (*embonpoint*, in French) is consistent with health, and is not opposed to beauty, as it prevents angularity and unevenness in the surface of the body, and gives the parts rotundity. For this reason, moderately corpulent women and men preserve a beautiful and youthful appearance longer than lean persons.

But if corpulence is excessive, it becomes troublesome, and, at length, dangerous. Water should then be drank instead of wine; milk, beer, and brandy should be avoided; active bodily exercise should be taken, and employment provided for the mind. Anxiety soon takes off superfluous fat, though grief sometimes produces it. In what cases medicine is to be resorted to, and what kinds should be used, must be left to the judgment of physicians. People sometimes resort to violent and injurious means to rid themselves of superfluous flesh. Madame Stich, the best actress in the theatre at Berlin, took poison to reduce her person to the right dimensions for performing Shakspeare's Juliet, and succeeded, though at the expense of her health. Instances of leanness as remarkable as those of corpulence are by no means rare. In 1825, a person was exhibited in England, who was not unaptly termed the living skeleton, and in 1830, a native of Vermont exhibited himself in the United States, under the same title. His legs and arms were almost entirely deprived of flesh. The man was about 45 years old, and weighed 60 pounds.

Corridor, in *architecture;* a gallery or long aisle leading to several chambers at a distance from each other, sometimes wholly enclosed, sometimes open on one side. In fortification, *corridor* signifies the same as *covert-way*.

Corrosives, in *surgery*, are medicines which corrode whatever part of the body they are applied to; such are burnt alum, white precipitate of mercury, white vitriol, red precipitate of mercury, butter of antimony, lapis infernalis, &c.

Corrosive Sublimate. See Mercury.

Corset; an article of dress, especially intended to preserve or display the beauties of the female form. Its name appears to have been derived from its peculiar action of tightening or compressing the body, and may be compounded of the French words *corps* and *serrer*. To prevent the form from too early showing the inroads of time; to guard it from slight inelegances, resulting from improper position, or the character of exterior drapery; to secure the proportions of the bust from compression or displacement; and, at once, agreeably to display the general contour of the figure, without impeding the gracefulness of its motions, or the gentle undulations caused by natural respiration, are the legitimate objects of the corset. For this purpose, it should be composed of the smoothest and most elastic materials, should be accurately adapted to the individual wearer, so that no point may receive undue pressure, and should never be drawn so tight as to interfere with perfectly free breathing, or with graceful attitudes and movements.

If, however, it be remembered that the use of corsets is to preserve and display a fine figure, not to *make* one, and that they are to be secondary to a judicious course of diet and exercise, it will be readily perceived that any injurious agents are utterly uncalled for in their composition. By selecting a material proportioned, in its thickness and elasticity, to the size, age, &c., of the wearer, and by a proper employment of quilting and wadding, they may be made of any proper or allowable degree of stiffness. If it be then accurately fitted to the shape of the individual, and laced no tighter than to apply it comfortably, all the advantages of the corset may be fully obtained. But such, unfortunately, is not the course generally pursued. Ladies purchase corsets of the most fashionable makers, and of the most fashionable patterns and materials, regardless of the peculiarities of their own figures, which may require a construction and material of very different description. As no two human figures are precisely alike, it is absolutely requisite that the corset should be suited with the minutest accuracy to the wearer; and a naturally good figure cannot derive advantage from any corset but one constructed and adapted in the manner above indicated. Slight irregularities or defects may be remedied or rendered inconspicuous, by judicious application of wadding, or by interposing an additional thickness of the cloth. But it should be remembered that certain changes occur to the female frame, after the cares of maternity have commenced, which are absolutely unavoidable. Among these, the general enlargement or filling up of the figure is the most observable, but is never productive of inelegance, unless it takes place very disproportionately. The undue enlargement of the bust and waist is most dreaded, and the attempt to restrain their developement by mere force has led to the most pernicious abuse of the corset. There is no doubt but that a judiciously fitted corset, whose object should be to support and gently compress, might, in such cases, be advantageously worn; but, at the same time, it must be thoroughly understood, that the corset can only be really beneficial when combined with a proper attention to diet and exercise.

Thus many ladies, who dread the disfigurement produced by obesity, and constantly wear the most unyielding and uncomfortable corsets, lead an en-

tirely inactive life, and indulge in rich and luxurious food. Under such circumstances, it is vain to hope that beauty of figure can be maintained by corsets, or that they can effect any other purpose than that of cramping and restraining the movements, and causing discomfort to the wearer. On the other hand, proper exercise, and abstinence from all but the simplest food, would enable the corset to perform its part to the greatest advantage. There is another error, in relation to corsets, as prejudicial as it is general, and calling for the serious attention of all those concerned in the education of young ladies. This error is the belief that girls, just approaching their majority should be constantly kept under the influence of corsets, in order to *form* their figures. They are, therefore, subjected to a discipline of strict lacing, at a period when, of all others, its tendency is to produce the most extensive mischief. At this time, all the organs of the body are in a state of energetic augmentation; and interference with the proper expansion of any one set is productive of permanent injury to the whole. So far from making a fine form, the tendency is directly the reverse, since the restraint of the corsets detrimentally interferes with the perfection of the frame. The muscles, being compressed and held inactive, neither acquire their due size nor strength; and a stiff, awkward carriage, with a thin, flat, ungraceful, inelegant person, is the too frequent result of such injudicious treatment.

We may conclude what we have to say on the use of the corset, by embodying the whole in a few plain general rules:—1st. Corsets should be made of smooth, soft, elastic materials. 2d. They should be accurately fitted and modified to suit the peculiarities of figure of each wearer. 3d. No other stiffening should be used but that of quilting or padding; the bones, steel, &c., should be left to the deformed or diseased, for whom they were originally intended. 4th. Corsets should never be drawn so tight as to impede regular, natural breathing, as, under all circumstances, the improvement of figure is insufficient to compensate for the air of awkward restraint caused by such lacing. 5th. They should never be worn, either loosely or tightly, during the hours appropriated to sleep, as, by impeding respiration, and accumulating the heat of the system improperly, they invariably injure. 6th. The corset for young persons should be of the simplest character, and worn in the lightest and easiest manner, allowing their lungs full play, and giving the form its fullest opportunity for expansion.

Corvette; a vessel of war having fewer than 20 guns.

Costume, in the *fine arts;* the observance of propriety in regard to the person or thing represented, so that the scene of action, the habits, arms, proportions, &c., are properly imitated. The peculiarities of form, physiognomy, complexion, the dress, ornaments, habitations, furniture, arms, &c., should all be conformable to the period and country in which the scene is laid. The rules of costume would be violated by the introduction of a palm-grove and a tiger in a scene in Russia, by the representation of American Indians in turbans, or of Romans with cannons at the siege of Carthage, or an inhabitant of the East seated at table with a knive and fork.

That the ancient painters, and even celebrated masters of the modern European schools, are often chargeable with deviations from propriety in regard to costume, is not to be denied; but nowhere have they been so glaring as on the stage, where Greek, Turkish and Peruvian princes used to make their appearance in long velvet mantles, embroidered with gold; Merope and Cleopatra were equipped in hoop-petticoats, Medea and Phædra in French head-dresses; peasant-girls were dressed out in whalebone, and heroes emerged from the battle in stiff coats, not a fold of which was disordered. Le Kain and Mademoiselle Clairon, it is said, were the first who introduced propriety of costume on the stage, under the patronage of the Count de Lauraguais; but they excluded only the grosser absurdities; Scythians and Sarmatians were clothed in tiger-skins, Asiatics in the Turkish dress; but the old costume was retained in other respects. The scenery of the stage was as incongruous as the dresses.

It is not long since Semiramis issued from a palace adorned with Corinthian columns, and entered a garden in which a whole American Flora was blooming; or perhaps she was seated on a throne, overshadowed with a canopy *à la Polonaise*. Those by whom she was surrounded were dressed in the Turkish style; while a master of horse, in the costume of the age of chivalry, offered her his hand. In Germany, the stage at that time, was no better in this respect. It is not very long since the companions of Theseus made their appearance there with large perukes; and, in the *Clemenza di Tito*, Roman soldiers marched on the stage with stiff boots, and stiffer queues. The Germans, however, first made a thorough reform in these absurdities, and the national, now royal, theatre, in Berlin, in point of scenery and costume, is at present one of the most correct in the world. In France, Talma reformed the Parisian stage. What he did in this respect for the drama, David (who had, however, a predecessor in Vienna) effected for painting, and his school is entitled to the honour of having strictly observed propriety of costume. In England, also, a most praiseworthy attention is now paid to propriety in dramatic costume, especially at the Theatre Royal, Covent Garden, where Mr. J. P. Kemble set a noble example of accuracy and splendour in the dresses and decorations, which he had made for the first production of the historical plays of Shakspeare, in the new house. Since his time, the same laudable path has been trodden by the proprietors and managers of that establishment, under the direction of Mr. J. R. Planché and others, with all the advantages which extended research and new sources of information can impart to the subject.

There is often no means of information for the artist but the original sources. For the costume of the ancients, he must have recourse to the engravings of antiquities; for the modern costume, he must resort to essays on painting in different ages, monumental figures, and treatises on costume; and in regard to the costume of foreign nations, he may derive information from books of travels; histories, antiquities and geographies, are indispensable guides in these inquiries. All the important peculiarities of foreign costume will be found depicted in the geographical division of this work.

Cotton is a soft, vegetable down, which is contained in the seed-vessels, and envelopes the seeds, of the cotton plant, which is cultivated in the East and West Indies, North and South America, and Egypt; in fact, in most parts of the world which possess a

sufficiently warm climate. The cotton-pods are of somewhat triangular shape, and have each three cells. These, when ripe, burst open, and disclose their snow-white or yellowish contents, in the midst of which are contained the seeds, in shape somewhat resembling those of grapes. The fibres of cotton are extremely fine, delicate, and flexile. When examined by the microscope, they are found to be somewhat flat, and two-edged or triangular. Their direction is not strait, but contorted, so that the locks can be extended or drawn out without doing violence to the fibres. These threads are finely toothed, which explains the cause of their adhering together with greater facility than those of bombax and several *apocyneæ*, which are destitute of teeth, and which cannot be spun into thread without an admixture of cotton.

The increase of the cotton manufacture, during the last half century, is one of the most interesting events in the history of commerce. The earliest seat of the manufacture, known to us, was Hindostan, where it continues to be carried on, by hand labour, in all its original simplicity.

Those who have seen the wonderful powers exhibited by the machinery of Hargraves and Arkwright, would scarcely conceive the process still employed in our own eastern possessions; and nothing but the jealousy of the British governors in the East could have so completely retarded the progress of improvement as is the case through the whole of Hindostan. We give an engraving of this primeval process, originally copied from a curious Hindoo MS.

Such has been the power of improved machinery, in its recent application to the spinning of cotton and its general manufacture, that Great Britain and America are now pouring back upon Asia her original manufacture, and underselling her in her own markets. The first impulse in these improvements was derived from the inventions of Hargraves and Arkwright, between 1767 and 1780.

The improved machinery of which we speak consists of the cylindrical carding engine, by which the fibres of cotton are disentangled and separated from each other, and from all foreign substances, and delivered in a uniform, continuous roll; the drawing and roving frames, by which these rolls are repeatedly doubled and extended, until the fibres are drawn out in a regular and perfectly horizontal position; and the spinning frame, the most important quality of which is the causing the roving or preparatory yarn to pass through two or more sets of rollers, revolving with different velocities, by which the thread, at the moment of being twisted, is drawn out to any desired degree of tenuity; the rollers performing the delicate office of the thumb and finger. In addition to these, the power-loom was brought into general use about the year 1816, by which the laborious process of weaving is converted into the mere superintendence of two, and even three, of these machines; each one producing from 30 to 40 yards of cloth per day. In the printing of calicoes, equally important improvements have been made.

Instead of the tedious process of impressing patterns from wooden blocks, the most delicate patterns are transferred from copper cylinders with astonishing rapidity; two, and even three, colours are, in this way, imprinted at one operation. In the richer and more expensive patterns, however, block-printing continues to be used, in addition to the impressions from the cylinders. The science of chemistry has contributed its share of improvement in the new process of bleaching by chlorine, and in innumerable new combinations of colours. In its present state, the entire manufacture, in its various departments, presents a greater combination of human skill than can be found in any other art or manufacture.

In 1781, the quantity of cotton wool imported into Great Britain was upwards of 5,000,000lbs; in 1829, it exceeded 218,000,000; and, allowing 20,000,000 for export, 190,000,000 pounds will remain as the consumption of the kingdom. Of this, upwards of 40,000,000 pounds are exported in yarns, valued at 3,500,000*l*. sterling. The value of other manufactures of cotton, exported in 1828, was 13,545,638*l*. The most probable estimate of the annual value of the cotton manufactured in Great Britain is 36,000,000*l*. sterling.

In the early periods of this manufacture, the profits must have been enormous. It has built up the cities of Liverpool and Manchester, of Glasgow and Paisley, and has been estimated to give employment to a million of persons. After a long period of success, interrupted only by occasional and temporary fluctuations, the production, both of the raw material, and of the manufactured article, seems to have outrun the consumption of the world, in that eventful year of overtrade, 1825. A long stagnation succeeded in 1826; an unprecedented reduction in the prices of cotton manufactures, and in the value of property engaged in it, spread a wide and general distress, throughout the districts devoted to this manufacture, which continued, with greater or less intensity, through the years 1828 and 1829.

Although there is no diminution in the quantity of cotton consumed in Great Britain, there is abundant evidence, that neither the capital nor labour employed in it is now receiving a fair remuneration. The fall in the prices of cotton manufactures, from 1814 to 1826, would seem, by a comparison of the real or declared value of the exports with the official value, rated by a uniform list, to have been 55 per cent. The greatest export in value, of any one year, up to 1815, having exceeded 19,000,000*l*. sterling.

We annex an important official document, which will best show the value of the cotton trade to Great Britain:—

Account of the Export of Cotton Goods and Yarn in 1829; *specifying the countries to which they were sent, and the quantity and value of those sent to each.*

Countries to which Cotton is Exported.	Cotton Manufactures.			Cotton Twist and Yarn.	
	Entered by the Yard.		Hosiery, Lace, and Small Wares.		
	Quantity. *	Declared Value.	Declared Value.	Quantity.	Declared Value.
	Yds.	£.	£.	lbs.	£.
Northern Europe:—Russia	2,453,676	94,872	23,146	17,921,369	1,062,225
Sweden	12,986	538	205	320,660	18,929
Norway	574,650	20,543	2,296	16,242	890
Denmark	352,097	8,439	429	85,161	5,222
Prussia	17,725	517	405	42,878	3,792
Germany	41,019,652	1,137,532	279,355	24,055,423	1,585,979
The Netherlands	11,399,792	443,705	214,681	7,878,249	673,714
Southern Europe:—France	509,030	15,462	3,335	19,500	1,486
Portugal, Proper	24,701,993	631,125	12,385	159,567	14,083
——— Azores	466,326	13,108	521	1,400	63
——— Madeira	502,631	14,602	616	12	1
Spain, and the Balearic Islands	11,018,689	326,708	12,978	17,620	1,475
——— Canaries	712,424	21,767	1,206	3,054	224
Gibraltar	10,242,089	310,723	10,052	21,873	2,194
Italy, and the Italian Islands	36,808,440	1,081,461	44,849	6,355,154	317,580
Malta	4,628,367	105,995	1,869	438,640	21,528
Ionian Islands	96,028	3,141	66	15,100	858
Turkey and Continental Greece	15,536,350	392,725	1,431	662,538	39,918
Africa:—Egypt, (Ports on the Mediterranean)	1,875,161	43,410	—	28	2
Western Coast of Africa	1,910,940	70,104	115	—	—
Cape of Good Hope	2,520,127	75,310	6,363	3,331	339
St. Helena	31,597	1,048	173	1	1
Mauritius	1,658,937	53,150	7,845	—	—
Asia:—East India Company's Territories, Ceylon, and China	39,733,698	1,267,216	28,395	3,185,689	210,182
Sumatra, Java, and other Islands of the Indian Seas	8,502,163	121,036	447	—	—
Philippine Islands	93,279	4,448	—	—	—
New South Wales, Van Dieman's Land, and Swan River	476,065	19,067	3,498	4,805	479
New Zealand, and South Sea Islands	2,008	80	—	—	—
America:—British Northern Colonies	8,671,237	261,546	16,191	84,760	4,477
British West Indies	33,319,295	997,408	52,872	1,230	195
Hayti	6,654,839	207,630	3,065	616	144
Cuba, and other Foreign West Indies	11,447,514	395,288	11,906	50	5
United States of America	32,552,162	1,346,023	155,334	30,182	1,928
States of Central and Southern America; viz. Mexico	6,007,047	204,677	9,441	97,320	6,660
Columbia	4,277,904	132,526	5,918	—	—
Brazil	50,077,739	1,437,963	50,369	5,300	679
States of the Rio de la Plata	15,429,383	485,381	24,657	5,460	506
Chili	16,972,286	570,863	22,508	2,735	327
Peru	3,465,460	143,798	15,689	800	48
Isles of Guernsey, Jersey, Alderney, Man, &c.	785,510	55,312	17,269	4,554	741
Total Exported	402,517,196	12,516,247	1,041,885	61,441,251	3,976,874

For a full account of the mechanical processes, see SPINNING, WEAVING, &c.

COUCHANT; an heraldic term to express an animal lying close to the ground, having the head erect in order to distinguish him from an animal *dormant*.

COUCHING, in *surgery;* an operation that consists in removing the opaque lens out of the axis of vision, by means of a needle constructed for the purpose of effecting that object.

COUGH, in *medicine;* a deep inspiration of air, followed by a sudden, violent, and sonorous expiration, in a great measure involuntary, and excited by a sensation of the presence of some irritating cause in the lungs or windpipe. The organs of respiration are so constructed, that every foreign substance, except atmospheric air, offends them. The smallest drop of water, entering the windpipe, is sufficient to produce a violent coughing, by which the organs labour to expel the irritating substance. A similar effect is produced by inhaling smoke, dust, &c. The sudden expulsion of air from the lungs is produced by the violent contraction of the diaphragm and the muscles of the breast and ribs. These parts are thus affected by a sympathy with the organs of respiration, which sympathy springs from the connection of the nerves of the different parts.

The sensation of obstruction or irritation, which gives rise to cough, though sometimes perceived in the chest, especially near the pit of the stomach, is most commonly confined to the *trachea*, or windpipe, and especially to its aperture in the throat, termed the *glottis*. Yet this is seldom the seat of the irritating cause, which is generally situated at some distance from it, and often in parts unconnected by structure or proximity with the organs of respiration. Of the various irritations which give rise to cough, some occur within the cavity of the chest; others are external to that cavity; some exist even in the viscera of the pelvis. Of those causes of cough which take place within the chest, the disorders of the lungs themselves are the most common, especially the inflammation of the mucous membranes, which excites the catarrhal cough, or common cold. This disease is generally considered unimportant, particularly if there be no fever connected with it. But every cough, lasting longer than a fortnight or three weeks, is suspicious, and ought to be medically treated. Another common cause of cough, which has its seat in the lungs, is inflammation of those organs, whether in the form of pleurisy or peripneumony.

These diseases do not differ very essentially, except in violence and extent, from the acute catarrh, but are more dangerous, and more rapid in their progress, and the constitution is excited to a highly febrile condition. Even after the acute state of inflammation may have subsided, a cough, attended with extreme danger, sometimes continues to be excited by collections of pus, or abcesses, which ensue in the substance of the lungs, and either terminate in consumption, or suffocate the patient by suddenly bursting; more rarely the pus is discharged gradually from a small aperture, and the patient recovers. In such cases, the fever, originally acute, is converted into a hectic, with daily chills, succeeded by heat and flushing of the face, night sweats, and emaciation.

Another frequent origin of cough is the rupture of some of the blood-vessels of the lungs, and the consequent effusion of blood into the cells, which is expelled by the cough that its irritation excites, constituting what is technically termed *hæmoptoe, hæmoptysis*, or spitting of blood. When the vessels of the lungs are thus ruptured, they seldom heal readily, but degenerate into ulcers, which pour out a purulent matter; and, by this discharge, the vital powers are gradually worn down and destroyed. This is a common source of consumption, or *phtisis pulmonalis*.

A cough is excited, and the same fatal disorder is also induced, by the existence of tubercles in the lungs. These are little tumours, which gradually inflame and ulcerate, and produce the same consequences as the ulcerations from *hæmoptysis*. *Calculi*, or stony concretions, are sometimes formed in the lungs, and the irritation which they produce necessarily excites a cough, which is liable to terminate in consumption. There is yet another source of irritation within the lungs, of which cough is an attendant, namely, an effusion of *serum*, into the parenchymatous substance of the lungs, or into the cellular membrane, which connects the cells and blood-vessels together. This has been called *anasarca pulmonum*, or dropsy of the lungs, and is marked by great difficulty of breathing, with a sense of weight and oppression in the chest, occasioned by the compression of the air-cells and vessels by the accumulated water; hence also great irregularity of pulse, frightful dreams, imperfect sleep, &c., are among its symptoms.

Inflammation of the heart, and of the *pericardium*, or membrane surrounding it, is also accompanied by cough, and other symptoms not easily distinguishable from those of pleurisy and peripneumony. Where a cough is excited by disorders of parts external to the cavity of the chest, it is generally dry, as the irritating cause is external, and not any obstructing matter in the lungs themselves. Disorders of the viscera of the abdomen, especially of those which lie in contact with the diaphragm (the muscular curtain separating the cavities of the belly and chest), frequently induce a cough.

A short, dry cough invariably attends inflammation of the liver, whether acute or chronic, and accompanies the various tubercular and other obstructions in that organ. Hence inflammation of the liver is not unfrequently mistaken for inflammation of the lungs; and, in some of the chronic disorders of the liver, the cough is occasionally complained of as the most urgent symptom. The presence of pain in the right side, shooting up to the top of the shoulder, the dryness of the cough, and pain, enlargement, hardness, or uneasiness on pressure below the ribs of that side, will afford the best means of distinguishing whether a disease of the liver is the origin of the cough.

Disorders of the stomach are, also, often accompanied with a cough of the same dry and teasing nature, especially when that organ is over distended with food, or is in the opposite condition of emptiness. A short cough is, therefore, a frequent symptom of indigestion and hypocondriasis, or of that weakness of the stomach which is popularly termed *bilious*. In short, there is scarcely any one of the viscera, in the cavity of the abdomen, the irritation of which, in a state of disease, has not excited cough. Disorders of the spleen, pancreas, and even the kidneys, have all given rise to this symptom; and external tumours attached to them, have had the same effect. Any distention of the abdomen, which, by

its pressure upwards, impedes the descent of the diaphragm, and consequently the expansion of the lungs, occasions cough. Thus, in the *ascites*, or dropsy of the belly, the water—in tympanites, the air—in corpulency, the fat in the omentum—and, in pregnancy, the gravid uterus,—all have the effect of exciting cough in many constitutions. The variety of causes from which coughs may arise, must convince every reader of the absurdity of attempting to cure all kinds of cough by the same remedy.

Course, in *navigation;* that point of the compass or horizon on which the ship steers.

Course, in *architecture;* a continued range of bricks or stones, level or of the same height throughout the length of a whole building, without being interrupted by any apparent aperture.

Counterguards, in *fortification*, are small ramparts with parapets and ditches, to cover some part of the body of a place. They are of several shapes, and differently situated. They are generally made before the bastion, in order to cover the opposite flanks from being seen from the covert-way, and, in this case, consist of two faces, making a salient angle parallel to the faces of the bastion. They are sometimes made before the ravelins. The cost of building them is more than proportionate to their value, especially when they are small, and without cannon, in which case, particularly, they are called *couvrefaces*.

Countermark, in *numismatics*. Antiquaries call by this name those stamps or impressions which are found on ancient coins or medals, and have been given since their first impress in the mint. These countermarks or stamps are often executed without any care, and frequently obliterate the most interesting portion of the original inscription. Thus they correspond with the *codices rescripti*. In performing this operation, the new mark was stamped upon the coin with a heavy blow of a mallet upon a punch, on which was engraved the countermark, of a round, oval, or square shape. The use of countermarks appears to have been first adopted by the Greeks, but it is impossible to say at what period of their history. Upon the Greek coins so altered, the countermarks are generally figures, accompanied by inscriptions. Those of Rome seldom contain any thing more than inscriptions and monograms.

There have been various opinions respecting the cause of these countermarks; some antiquaries thinking that they were to indicate an augmentation of the value of the money upon which they were stamped; others, that they were vouchers for workmen; and, again that they were only struck upon money taken or received from foreign enemies. Jobert, Millin, De Boze, Bimard, Mabudel, Pelleim, Florez, and other antiquaries, have exercised their conjectural skill on this subject. During the long war with revolutionary France, England stamped millions of Spanish dollars with small, oval countermarks of the head of George III. upon the neck of the Spanish monarch. Many of them were completely restamped or countermarked in the mint, and both impressions were sometimes visible, the English head and reverse not completely destroying the Spanish head, armorial bearings, and inscriptions.

Counterpoint signifies, in *music*, a part or parts added to a given melody. In ancient times, musical sounds were represented by certain letters of the alphabet. A great improvement was made on the old system by the celebrated Guido d'Arezzo, who substituted points or dots in the place of letters. The simple harmony of that period consisted of notes equal in length, and the term *contrapunctus*, or *counterpoint* was applied to it in consequence of the points by which it was represented being placed under, or, as it were, against each other, on the staff. By *counterpoint*, we understand, therefore, the several parts which compose musical harmony; and the science of counterpoint consists in a knowledge of the rules according to which those parts must be constructed. On this account, the term is fequently used for musical composition in general. When the notes employed are of equal length, the counterpoint is called *simple*. When notes of various length are used, the counterpoint is said to be *figurate* or *florid*.

Counterpointed, in *heraldry*, is when two cheverons in one escutcheon meet in the points, the one rising as usual from the base, and the other inverted falling from the chief, so that they are counter to one another in the the points. They may also be counterpointed when they are founded upon the sides of the shield and the points meet that way, called counterpointed in fesse.

Counterpoise, in *mechanics;* a weight standing in opposition to another weight. Thus when a weight is placed on each side of a beam, so that neither of the two preponderates, each weight is said to be a counterpoise to each other.

Counterproof, in *engraving;* an impression taken from a newly-printed proof of a copperplate, for the purpose of a closer investigation of the state of the plate, as the proof is, in every respect, the reverse of the plate, while the counterproof has everything the same way.

Counter Salient, in *heraldry*, is when two lions are borne in a coat, leaping from each other, directly in the contrary way.

Counterscarp, in *fortification*, is properly the slope or *talus* of the exterior side of a ditch, towards the field. The inner slope, on the side towards the place, is called *escarpe*. Sometimes the covert-way and glacis are termed *counterscarp*.

Coup. This term is used in various connections, to convey the idea of promptness and force. *Coup de main*, in military language, signifies a prompt, vigorous, and successful attack. *Coup d'œil*, in a military sense, a rapid conception of the advantages and weaknesses of positions and arrangements of troops. It is also used for a quick comprehension of all the points and bearings of any subject. *Coup de théâtre*, a sudden and striking change in the action. *Coup d'état* is a forcible and arbitrary political measure.

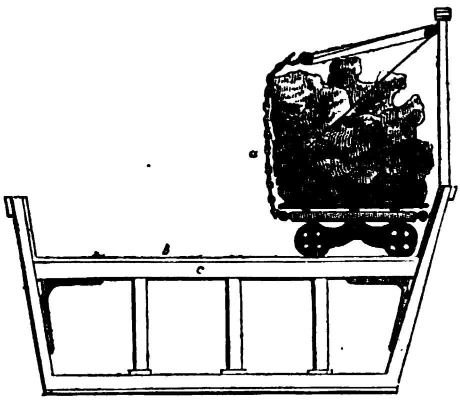
Coupurus, in *fortification*, are passages sometimes cut through the glacis, of about twelve or fifteen feet broad, in the re-entering angle of the covert-way, to facilitate the sallies of the besieged. They are sometimes made through the lower curtain, to let boats into a little haven, built on the re-entering angle of the counterscarp of the out-works.

Covered-Way; a space of ground on the edge of the ditch, ranging round the works of a fortification. Its glacis descends by an easy slope, towards the field. It affords a safe communication round all the works, facilitates sallies and retreats, and the reception of auxiliaries, compels the enemy to begin his operations at a distance, checks his approach and the erection of

breach batteries, and its parapet protects the fortifications in its rear.

Cowry-Shells; shells used for coin; a kind of small muscles, belonging to the Indian seas, &c.— The largest are an inch and a half in size, and indented on both sides of the opening. They are collected twice a year in the bay of Bengal, on the Malabar coast, and, in still greater quantity, in the neighbourhood of the Maldive islands. They are used throughout the East Indies, especially in Bengal and in the African trade, instead of small coins. The demand is so great, that, notwithstanding the insignificant price (in 1780, a pound of them might be bought for three cents), about 150,000 dollars worth are sent every year to Bengal.

Crab, in *ship-building;* a very common substitute for the capstan. We notice this mechanical arrangement, to describe one which was employed in the erection of the Breakwater at Plymouth: it is represented beneath.



A strong flat-bottomed vessel furnished with a deck, at *c*, of which we show a section, was employed for the transport of stones from the quarry to the site of the work. The carriage with the block was then rolled along the line *b*, to the side of the vessel; the chain *a*, raised by the blocks above, and when it attained a certain angle, precipitated into the sea.— The stones deposited by this means exceeded five tons in weight. Of this gigantic work we shall give a full account under Plymouth, in the Second Division of this work.

Cradle, in *ship-building;* a frame placed under the bottom of a ship, in order to conduct her, smoothly and steadily into the water, when she is launched; at which time it supports her weight whilst she slides down the descent or sloping passage called the *ways*, which, to facilitate her passage, are coated with soap and tallow.

Craft, in sea language, signifies all manner of nets, lines, hooks, &c. used in fishing. Hence little vessels, as ketches, hoys, smacks, &c., of the kind commonly used in the fishing trade, are called *small craft.*

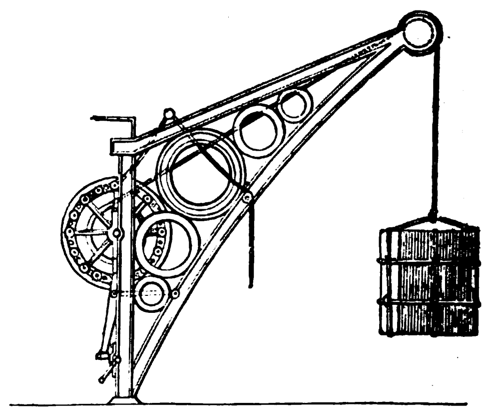
Cramp, in *architecture* and *sculpture;* pieces of iron, bronze, or other metal, bent at each end, by which stones in buildings, and limbs, &c., of statues, are held together. The ancient Romans made great use of cramps in their buildings, and the cupidity of modern barbarians, like Pope Barberini, has destroyed many a fine work for the sake of the bronze used in its construction. The Pantheon, with its fine portico, by Agrippa, and the Coliseum have suffered most from these wanton aggressions, and the baldachin of St. Peter's, and some eighty pieces of brass ordnance, are nearly all that we have in exchange for some of the finest works of which the world could boast.

Cramp, in *medicine*. See Spasm.

Crane, in *mechanics;* a very useful instrument for raising great weights. A crane usually consists of a jib or projecting lever, furnished with two pulleys, round which a rope or chain is coiled, so that while the weight to be raised is attached to one end of the cord, the other passing over a second pulley, descends to a wheel and axle to which animal power is applied.

Cranes thus constructed are found at the large warehouses in which heavy goods are deposited. Even this species of instrument might, however, be rendered much more useful than it now is, by attaching it to the large luggage carts used in the metropolis, instead of trusting to the remote contingency of finding the apparatus in order at the retail shopkeepers where parcels are delivered. The streets would not in that case be impeded as they now are by temporary inclined planes and large barrels, which block up the foot-path.

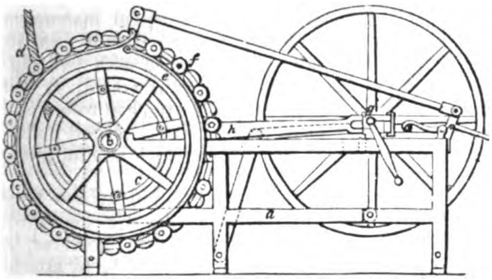
We may now notice a very great improvement on the crane, by Mr. Wright, which materially diminishes the labour of those employed. A view of the machine is given in the engraving beneath.



This crane consists of a novel combination of mechanical powers, constructed without either toothed wheel or pinion, its whole power being derived from a peculiar adaptation of the lever and wedge. These are made to act on rollers, mounted on wheels, which are attached to the drum or barrel that the draft-rope or chain winds upon.

Before we examine the working part of the chain, it may be proper to say, that that part of the patent which relates to the employment of compressed air as a substitute for the labour of men, is of no practical utility, and altogether as fallacious as the crane itself is ingenious. In the section on the accompanying page, *a* represents the side standard which supports the pivot, *b*, of the barrel or drum, *c*, round which the draf-trope or chain, *d*, is wound; *e* is a wheel or circular rim affixed to the axle of the drum. This rim carries a series of friction rollers, *f*, &c. mounted on pins, projecting

alternately from each side of the wheel. A four-throw crank, *g*, turns in a swinging frame; and to each of the cranks is attached a lever as at *h*, with a wedge-formed end which acts on the rollers. At one end of the crank shaft is a fly-wheel, to regulate the motion of the machine.



On the power being applied to the cranks, *g*, by the winch handles, or by any other means, the cranks as they revolve towards the drum wheels project forward; the levers and their wedge-formed ends successively pass under and raise the rollers, and when past their centres revolving from the drum wheels the cranks depress the longer arms of the levers, and raise the shorter arms with the rollers, and thus successively drive round the rims, and with them the drum or barrel.

To throw the machine out of gear, the ends of the levers must be withdrawn from the friction rollers; to do this, the pauls must be removed from supporting or wedging up the back of the swinging frame, by lifting up the handle on the shaft, when the frame with the crank shaft and levers may be drawn back against a rest.

The crank and levers being thus out of gear, the barrel is at liberty to turn the reverse way, for the purpose of lowering the weight suspended, and the velocity of the descent is to be regulated by a two-part break, as shown in our first figure.

When it is required to put the machine into action, the counter-balance weight hung over the pulley by a chain or rope from the swinging frame, will assist to bring the swinging frame up into its working position, when the pauls will fall down.

The following experiment was made with this crane in a large establishment before the Editor of the *London Journal of Science*:—

A common crane was worked by six men, accustomed to the work, while Mr. Wright's crane was worked by three bricklayer's labourers taken from the hod, and yet with these enormous disadvantages, as to strength and habit, the comparative work of the two cranes was very much in favour of Mr. Wright's new construction.

The weight raised by each crane and each set of men was 18 cwt.; and the space through which it was raised each time 30 feet.

The six men, with the common crane, worked 2 hours 23 minutes and 36 seconds, and hoisted the weight 81 times; being on an average once in every minute 46 seconds and four-tenths of a second.

The three men with Mr. Wright's crane, worked only 2 hours 10 minutes and 30 seconds (an accidental fracture of part of his machine causing it to stop sooner than the other), and hoisted the weight 46 times, being on an average once in every two minutes 50 seconds and two-tenths of a second.

To reduce the work done by the two sets of men to equal terms of comparison, we must,

First, equalize the time occupied:

	h.	m.	sec.
The six men worked	2	23	36
The three	2	10	30
Difference . .		13	6

So that we must deduct from the total number of hoists (81) made by the six men, the number of hoists in 13 minutes 6 seconds, which, at one hoist per minute 46 seconds and four-tenths, is nearly 8; say, however, only 7; this reduces the actual number of hoists made by the six men in the same space of time to 74.

Secondly, we must equalize the manual power employed; to do which we must take half only of the work done by the six men, or 37.

We have, then, for the work done in 2 hours 10 minutes 30 seconds, by three men, with the old crane 37

By three men, in the same time, with Mr. Wright's crane 46

Gain by the new crane . 9

The result of this experiment gives an advantage in favour of the new crane, of nearly one-fourth.

Cranium. A portion of the bony frame-work of the head is divided into the cranium proper or brain case, and the face.

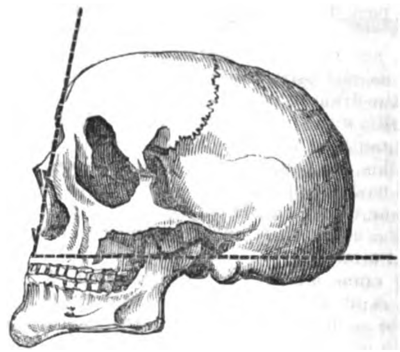
The bones of the cranium are composed of two compact plates called *tables*, an external, and an internal or vitreous table with an intervening loose bony structure called *diploë*,—a distinction which is not evident at the thinner parts of the bones, and which does not exist in the young subject or in the face. There is a considerable variation in the thickness and density of the skull. both in different parts and in various individuals; its inner surface is marked by the impressions of the brain which is most apparent at the base; there are also pits for the lodgment of glands and grooves, and canals for the passage of blood-vessels.

The cranium proper is composed of eight bones; viz. The occipital bone, 2 parietal bones, 2 temporal bones, the frontal, the sphenoid and the æthmoid bones, the three latter being common to the skull and face. The bones of the face are distributed into two divisions,—those of the upper jaw, and a single bone for the lower, the inferior maxillary bone: the upper jaw consists of six bones on each side, and one bone in the centre, making thirteen; viz., 2 nasal, 2 lachrymal, 2 malar, 2 superior maxillary, 2 palate, 2 inferior spongy bones, and the single bone called vomer from its resemblance to a ploughshare. The various bones of which the head is composed are connected by an immoveable species of articulation called *suture* (from the Latin word for *sewing*, *sutura*), which, when the soft structures are removed still retains the bones in apposition. These sutures are of three kinds,—1. The true or serrated suture, produced by numerous small processes of one bone being received into corresponding cavities of the opposed edge of another. 2. The squamous suture, where

one bone overlaps the other like the scales of a fish. 3. Harmonia or union by plain surfaces, by which suture principally the bones of the face are connected. The mode in which the teeth are implanted in their sockets is termed *gomphosis* from its *nail*-like character. Separate pieces of bone, varying in size and form, are found in the course of the sutures, and are called *ossa triquetra*, or *wormiana*. The sutures of the cranium proper are, the coronal, the sagittal, the lambdoidal, the 2 squamous sutures, the 2 additamenta suturæ squamosæ, and the 2 additamenta suturæ lambdoidalis. The sutures common to the cranium and face are, the transverse orbitar, the spheroidal, the æthmoidal, and the 2 zygomatic sutures. The sutures proper to the face are, the anterior nasal, the 2 lateral nasal, the 2 palato-maxillary, the 2 external and 2 internal orbitar, the longitudinal palate, the transverse palate, the spinous, the mystachial, and the 2 lachrymal sutures.

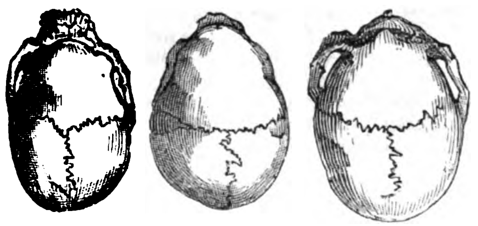
The bones, when connected form a cavity, or brain-case for the reception and protection of the brain; and as the skull is composed of an outer, tough, and fibrous, and an inner, brittle, or glassy table, we see a beautiful provision to avert the injurious effects of a jar or concussion of the brain from a blow or fall; the skilful adjustment of the bones by the serrated suture or dovetailing, and the overlaping of one bone over another, are also mechanical contrivances admirably adapted by infinite wisdom to give strength and stability to the cranial arch. At birth, the bones are in but an imperfect state, ossification is proceeding, having commenced at numerous central points and radiating towards the circumference: at the junction of the two parietal bones with the frontal, so great a membraneous space is left, that the pulsation communicated to the brain by its vessels can be felt, and this is called the *anterior fontanelle* or *bregma*, while a smaller space between the two parietal bones and the occipital is termed the *posterior fontanelle*. The frontal bone early in life consists of two portions united by a continuation of the sagittal suture, which at the adult period is generally, but not always, obliterated. Dr. Leach, who examined the immense collection of crania in the catacombs at Paris, remarked that the frontal suture remained unobliterated in about one out of eleven crania; and a similar observation respecting the frequency of crania with this suture unobliterated in the cemetery at Hythe, has induced the inference that they are Norman. The greatest diameter of the cranium is from the forehead to the occiput, and measures 6½ inches; the greatest transverse diameter is 5½ inches; the greatest perpendicular, 5 inches. The exterior of the skull is smooth and uniform, and does not generally correspond with the eminences and depressions made by the convolutions of the brain on the internal surface; the base however is irregular, and has numerous holes for the passage of vessels and the nerves proceeding from the brain. On each side of the skull is observed a remarkable hollow, called the *temporal fossa*, filled up in the recent state by the temporal muscle which closes the lower jaw. The bones of the face contribute principally to form the cavities of the orbit, nose, and mouth. The orbitar cavities are formed each by seven bones,—the frontal, sphenoid, æthmoid, superior maxillary, malar, lachrymal, and palate bones; they are of a square form, and in order to command a more extensive field for vision, face rather outwards. The bones of the nose are of a light thin texture, arranged so as to afford an extended surface for the olfactory membrane, and consist of all the bones of the face, with the exception of the two malar bones. The two superior maxillary bones have 16 *alveoli* or sockets, for the reception of the teeth of the upper jaw, while the inferior maxillary bone has the same number of sockets for the teeth of the lower jaw.

Observing the varying forms of the head and features, which not merely characterise distinct races of mankind, but are sufficiently striking even in individuals of the same nation, it is obvious that these peculiar conformations must essentially depend on the configuration of the bones of the head; accordingly, in comparing the crania of individuals of different nations, we find the national peculiarities as uniform as the colour of the skin and other distinctive characters. This interesting subject was however little attended to by anatomists until Camper ingeniously attempted by his *facial angle* to distinguish not only the crania of the human species, but to mark out the diversities of the animal kingdom, by establishing a scale ascending from animals of an inferior garde to the most beautiful and perfect specimens of the human cranium.



The cranium being viewed in profile, two imaginary lines must be drawn, one proceeding horizontally through the meatus auditorius externus and the floor of the nostrils, the other passing from the prominent part of the forehead to the alveolar projection of the upper jaw; thus, the angle formed by the junction of the two lines will be smallest in birds, in the monkey 42°, in the African Negro 70°, in the European 80° The ancients in the statues of their heroes and great characters, have made the facial angle 90°, while, to express the sublime majesty of a heathen god, it is increased to 100°. Considering therefore the relative proportions of the cranium and face in a vertical section of the head made longitudinally, the area of the cranium of the European is four times as large as that of the face; in the monkey they are about equal; whereas in ruminating animals the area of the face is about double that of the cranium. In applying the facial angle of Camper, the calculation is obscure and uncertain, it neither affords a correct estimate of the human intellect, as dependant upon the developement of the brain, nor furnishes a measure of the proportions in which animals are endowed with sagacity. As a means of distinguishing national variations in the conformation of the skull, it is objected, that it only indicates those va-

rieties of form which depend on the prominence and figure of the forehead and upper jaw, and gives no intimation of the breadth of the face or of any other peculiarities in the shape of the skull. Blumenbach possessing an extensive collection of crania of different nations, was able to make many important observations, and by remarking the variations in the breadth of the skulls of the inhabitants of different countries, and other striking differences in their configuration has arranged crania into five classes. The skulls must be placed in a line upon a table with their zygomas touching, and then viewed from behind, the eye being fixed on the vertex of each, so as to observe the variations in their shapes; this is termed the *vertical method*. The three classes most remarkably distinguished from each other are the *Caucasian*, *Mongolian*, and *Æthiopian*.

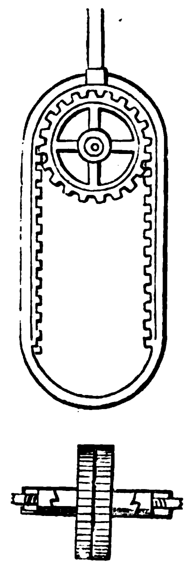


The central one, or Caucasian, includes the nations of Europe, the Western Asiatics, and the Northern Africans. Shape of the head, symmetrical—forehead well developed, concealing the face—face narrow—cheek-bones not projecting—chin full and round. Mongolian, or right hand figure, includes the Asiatics not comprehended in the first division, and the inhabitants of the northern parts of Europe and America. Head almost square—face broad—cheek-bones projecting outwards—nose flat—chin prominent. The Æthiopians, or extreme left, comprehends all the Africans not included in the first division. Head narrow, compressed at the sides—forehead convex—cheek-bones projecting forwards—jaws lengthened—front teeth projecting—large nasal cavity. The fourth, or American, including all the Americans except the inhabitants of the northern parts, may be placed between the Caucasian and the Mongolian. Cheek-bones prominent—forehead small and low—orbits deep—nasal cavity large. The last class, or Malay, being an intermediate link between the Caucasian and Æthiopian, comprehends the inhabitants of the numerous Asiatic islands, and those of the Great Pacific Ocean. Cranium narrow, and slanting at its upper and front part—face large—jaws prominent. Under this classification the crania of the various tribes of the human race may be arranged, with some exceptions.

The peculiarity in the configuration of the skull of some nations is not always natural, the most striking instance of which exists in the Caribean cranium, where, under a mistaken notion of beauty, the singularly depressed forehead is produced by artificial pressure in infancy. In consequence of the erect position of man, the great occipital foramen is placed nearly in the centre of the base of the skull, whereas in all animals it is placed behind the centre, and in most at the back part of the head. The want in man of the intermaxillary bone which is present in most animals, is considered by Camper as a characteristic of the human cranium. See Lawrance's *Physiological Lectures*; Pritchard's *Physical History of Mankind*; Blumenbach, *Decades craniorum diversarum gentium illustratæ*, Göttingen, 1800, 4to.

Crank, in *mechanics*; an iron axis with the end bent like an elbow, for the purpose of moving a piston, the saw in a sawmill, &c., causing it to rise and fall at every turn; also for turning a grindstone, &c. The common crank affords one of the simplest and most useful methods for changing circular into alternate motion, and *vice versa*. Double and triple cranks are likewise of the greatest use for transmitting circular motion to a distance. In fact, cranks belong to those few simple elements on which the most complicated machines rest, and which, like the lever, are constantly employed.

A patent has lately been taken out for an improvement of the crank, or rather it is intended as a mode of converting a reciprocating motion into a rotatory motion, as the vibratory action of the beam of a steam-engine, which is usually conveyed to the shaft through the agency of a crank, and thereby is caused to exert a rotatory power.



The parts which compose this apparatus are shown in the accompanying engraving. They consist of an eliptical frame to which racks are affixed; the central wheels are shown detached in the lower diagram. These wheels and their bosses slide loosely round the axle, and are severally locked to the axle, when the notch or clutch of the boss takes hold of the corresponding notch of the end pieces. These end pieces are confined to the axle by small projections fixed on the axle, called feathers or leaves, which fall into notches in the hollow part of the end pieces; these pieces are allowed to slide sideways, and are pressed up towards the wheels by spiral springs confined by the ends of the cylindrical case.

If it be supposed that the eliptical frame be attached by a perpendicular rod to the end of the vibrating beam of a steam-engine, and by that means be made to move up and down; the rack, as it descends, taking into the teeth of the wheel, will cause it to turn round, and the notch of its boss locking into the clutch or end piece, will drive the axle round with it in the same direction; but as the eliptical frame, ascends, the notch of the boss of the wheel will unlock itself, and the wheel will retrograde without affecting the axle. The other rack being opposite to the other wheel, which drives round its boss, now locking with the other end piece, causes the axle to continue revolving in the same direction as before.

Thus it will be perceived that the racks of the reciprocating frame, acting in the teeth of the wheels, will cause them to perform a reciprocating motion on their axis, and by their occasional locking to the clutch pieces, will communicate to the axle a continuous rotatory motion.

Crape; a light transparent stuff, like gauze, made

of raw silk or worsted, gummed and twisted on the mill, woven without crossing, and much used in mourning.—They are either craped or smooth. The silk destined for the first is more twisted than that for the second, it being the greater or less degree of twisting, especially of the warp, which produces he crisping given to it. Crapes are all dyed raw. This stuff came originally from Bologna; but, till of late years, Lyons is said to have had the chief manufacture of it. It is now manufactured in various parts of Great Britain. The crape brought from China is of a more substantial fabric.

Crayons; a general name for all coloured stones, earths, or other minerals and substances used in designing or painting in pastel, whether they have been beaten and reduced to a paste, or are used in their primitive consistence, after being sawn or cut into long narrow slips. The sticks of dry colours which go under this name, and which are cemented into a friable mass, by means of gum or size, and sometimes of clay, afford a very simple means of applying colours, being merely rubbed upon paper, after which the shades are blended or softened by means of a stump or small roll of leather or paper. The drawings require to be protected by a glass covering, to save them from being injured, unless some means have been adopted to fix them, so that they may not be liable to be rubbed off. This may be done by brushing the back of the paper with a strong solution of isinglass, or by passing the drawing through a powerful press, in contact with a moist paper.

Cream of Tartar. See Tartar.

Crescendo, or Cres. By the term *crescendo*, the Italians signify that the notes of the passage over which it is placed are to be gradually swelled. This operation is not of modern invention. The ancient Romans, as we learn from a passage in Cicero, were aware of its beauty, and practised it continually.

Crescendo is also the name of a musical instrument, invented in 1778, by the counsellor Bauer, in Berlin, which is played like a piano, and is furnished with wire strings.

Crest is used to signify the rising on the defensive armour of the head, also the ornament frequently affixed to the helmet, such as a plume or tuft of feathers, a bunch of horse-hair, &c. Warriors have always been in the habit of adorning their persons; and the helmet, from its conspicuousness, is very naturally chosen as the place of one of the principal ornaments. We learn from Homer (*Il.* iii. 336), that the crests of the earlier Greeks were of horse-hair; afterwards plumes, especially red ones, were adopted. (Virg. *Æn.* ix. 50, 271, 808.) To gain an enemy's crest was accounted an honourable atchievement, as it was reckoned among the *spolia*. The crests of commanders were generally larger than those of common soldiers.

In the middle ages, when rank and honours became hereditary, and particular heraldic devices were appropriated to particular families, the crest became a distinguishing hereditary mark of honour. It denotes, in heraldry, a figure placed upon a wreath, coronet; or cap of maintenance, above both helmet and shield; as, for instance, the crest of a bishop is the mitre. The crest is considered a greater criterion of nobility than the armour generally. It is commonly a piece of the arms, as that of Castile is a castle. Crests, therefore, form an important subject in the science of heraldry.

We take two very beautiful examples of the crest. The head on the right hand is ornamented with one of the richest and most beautiful of the Greek crests, The second belongs to the chivalry of modern times. It may be proper to add, that the Æginetan statues had crests ornamented with horse-hair, similar to those worn by many of our cavalry regiments in the present day.

Cretinism, in *medicine*, close approaches to rickets in its general symptoms. It differs principally in its tendency to that peculiar enlargement of the thyroid gland, which, in France, is denominated *goître*, and in the mental imbecility which accompanies it from the first. The enlargement of the gland does not always, however, accompany the other symptoms, though it does generally. Cretinism was first distinctly noticed and described by Plater, about the middle of the 17th century, as occurring among the peasants in Carinthia and the Valais. It was afterwards found, in a still severer degree, in other valleys of Switzerland, and the Alps generally. It has since been detected in various other regions, where the country exhibits similar features, as among a miserable race called *Cagots*, inhabiting the hollows of the Pyrenees, whose district and history have been described by Mr. Raymond; and in Chinese Tartary, where it is represented as existing by Sir George Staunton. On the first discovery of cretinism, it was ascribed by some to the use of snow-water, and by others to the use of water impregnated with calcareous earth, both which opinions are without foundation. The first is in a measure disproved by the fact that persons born in places contiguous to the glaciers, and who drink no other water than what flows from the melting of ice and snow, are not generally subject to this disorder; and, that the disorder is observed in places where snow is unknown. The second is contradicted by the fact, that the common water of Switzerland, instead of being impregnated with calcareous matter, excels that of most other countries in Europe in purity and flavour. The water usually drank at La Batia and Martigna is from the river Dranse, which flows from the glacier of St. Bernard, and falls into the Rhone. It is remarkably free from earthy matter, and well tasted. At Berne, the water is extremely pure; yet, as Haller remarks, swellings of the throat are not uncommon in both sexes, though cretinism is rare. As comfortable and

congenial warmth forms one of the best auxiliaries in attempting the cure of both cretinism and rickets, there can be no doubt that the chill of snow-water must considerably add to the general debility of the system when labouring under either of these diseases, though there seems no reason for supposing that it would give rise to either. It is not difficult to explain why water impregnated with calcareous earth should have been regarded as the cause; for in cretinism, as in rickets, the calcareous earth, designed by nature for the formation of the bones, is often separated, and floats loose in various fluids of the body, for want of a sufficiency of phosphoric acid to convert it into a phosphate of lime, and give it solidity. And as it is, in consequence, pretty freely discharged in the urine, this seems to have given rise to the opinion that such calcareous earth was introduced into the system with the common water of the lakes or rivers, and thus produced the morbid symptoms. M. de Saussure has assigned the following cause of the disease. The valleys of the Alps, he tells us, are surrounded by high mountains, sheltered from currents of fresh air, and exposed to the direct, and, what is worse, the reflected rays of the sun. They are marshy, and hence the atmosphere is humid, close, and oppressive; and when to these causes we add the meager, innutritious food of the poor of these districts, their indolence and uncleanliness, with a predisposition to the disease, from a hereditary taint of many generations, we can sufficiently account for the prevalence of cretinism in such places, and for the humiliating character which it assumes. The general symptoms of cretinism are the same as those of rickets; but the disease shows itself earlier, often at birth, and not unfrequently before this period, apparently commencing with the procreation of the fœtus, and affording the most evident proofs of ancestral contamination. The child, if not deformed and diseased at birth, soon becomes so; the body is stinted in its growth, and the organs in their developement.

Crisis, *in medicine;* a point in a disease, at which a decided change for the better or the worse takes place. The crisis is most strongly marked in the case of acute diseases, and with strong patients, particularly if the course of the disease is not checked by energetic treatment. At the approach of a crisis, the disease appears to take a more violent character, and the disturbance of the system reaches the highest point. If the change is for the better, the violent symptoms cease with a copious perspiration, or some other discharge from the system. In cases where the discharge may have been too violent, and the principal organs have been greatly deranged, or where the constitution is too weak to resist the disease, the patient's condition becomes worse. In regular fevers, the crisis takes place on regular days, which are called *critical days* (the seventh, fourteenth, and twenty-first); sometimes, however, a little sooner or later, according to the climate and the constitution of the patient. A bad turn often produces a crisis somewhat sooner. When the turn is favourable, the crisis frequently occurs a little later. After a salutary crisis, the patient feels himself relieved, and the dangerous symptoms cease.

Crocket, in *architecture;* one of the small ornaments which are usually placed along the angles of pinnacles, and on the outside of pediments, tabernacles, and cupolas, in the pointed style of architecture. See Architecture.

Crocus, in *chemistry;* a term given by the older chemists to several preparations of metallic substances.

Croma, in *Italian music;* the character which in England is called a quaver.

Cromorne, in *music;* a reed stop in most of our old organs; its tone resembles a bassoon more than any other instrument.

Crop, in *agriculture,* usually signifies the corn gathered off a field in harvest.

Till the middle of the last century, the best common courses of farming in Britain consisted in a fallow, which by several ploughings, broke up and cleaned the ground, but left the soil exposed to the scorching rays of the sun, during the hottest season, without any shading crop; and on this the farmer sowed wheat, which was succeeded by peas or beans; then followed barley, or oats, or both, on one part of the farm, for the space of ten or twenty years: the other moiety, during that time, being laid out in common pasture grasses. When any change was to be made, the part in grass was ploughed and prepared, and then thrown into the same course, or rotation of crops as above: that which had been in crops was sown with mixed grass-seeds (but not clover), to lie ten or twenty years, as before. The whole arable part of the farm thus parcelled, included neither the homestead nor the standing meadow; so that an arable farm of 300 acres admitted of 150 being in grass lay, or old field, and 150 in crops. The fields which bore crops, were seldom equal in quantity; but in the following plan we have ventured to consider them so, for the better comparing the old and new systems.

No. I.

Acres.		Bushels.
37½	fallow, naked, yields nothing.	
37½	wheat	555
37½	peas or beans	555
37½	barley	740
		1850
150	in crops 4 fields	
150	in grass or hay.	
300	acres.	

The fallow, wheat, and barley crops are exhausting, that is, they deprive the land, by exhalation, of part of the vegetable nutriment deposited in it; the peas or beans, which operate as a manure, ameliorate; but the rays of the sun on the naked soil, in the hot season, cause a considerable portion of the essence of the manure, and also the ground, gradually to exhale.

The present system of rotation, or courses of crops, was introduced about the middle of the eighteenth century, and is founded on the following principles, namely; 1. To fallow, and at the same time to have a shading and ameliorating mild crop growing in the fallow, while it is under the plough or hoe; 2. Never to sow any species of corn in succession; 3. To sow clover, or an equivalent on every field of small grain; and lastly, by means of a course of well selected crops, to prevent the soil from resting, hardening, and running into weeds.

By this method, entire farms are continued in a constant rotation under four, six, or eight divisions, or fields, in such a manner as to improve the soil, and consequently to produce a larger income.

Acres.	No. II.	Bushels.
60	Barley	1200
60	Clover	—
60	Wheat	900
60	Clover	—
60	Peas or Beans	900
		3000

300 acres in 5 fields.

According to this new course, the wheat and barley exhaust the soil, while the clover and peas, or beans, ameliorate and improve it.

When we compare these two systems of rotation of crops, the latter is evidently the most profitable, as the 120 acres in clover are far superior to the 150 acres of common grasses on the "hide-bound" soil of the lay, or old field; and the grain and straw are more advantageous, in the proportion of 300 to 185. Clover, peas, and beans (if sown in drills, and kept clean from weeds by hoeing), are inoffensive, and even ameliorating.—They all shade the ground during the hottest season of the year. Every kind of corn impoverishes the soil, and, if small, lets in weeds, which, together with rest, bind and foul the land.

The superiority of the new course of crops is still farther evinced by a series of conclusive experiments made by the late A. Young. He divided three acres of old upland pasture into thirty-six squares of nine roods each, which he planted with beans, peas, wheat, barley, oats, cabbages, clover, potatoes, &c., in different rotations, with various success. From these comparative trials he drew the following practical inferences, which we recommend to the serious attention of our agricultural readers.

1. That potatoes exhaust the land more than any other fallow crop hitherto tried; and in some courses to a greater degree than barley or even wheat.

2. That potatoes will not yield a tolerable crop, even on old lay newly broken up, without the aid of dung, and not a profitable one even with it.

3. That barley, beans, and oats, succeed much better than wheat, after potatoes.

4. That beans are the most valuable fallow crop on new land of this quality.

5. That the promotion of the fertility of old turf, depends much on the number of bean crops introduced; as the more frequently they are planted, the better the succeeding crops of wheat corn will be: and three successive years of beans are attended with an extraordinary produce of wheat.

6. That beans and barley, and beans and wheat, alternately, are both courses of great produce and advantages.

7. That the introduction of beans in proper rotations, tends to remedy the evil of such courses.

8. That successive crops of white corn destroy that fertility which different rotations will preserve in new ground: and that three such crops will render the land extremely foul and unprofitable.

9. That the two most productive courses are, beans and barley alternately; the former being the most abundant, but the latter the most profitable from the saving of tillage.

10. That four crops of beans, and one of wheat, even with the drawback of one years' cabbages, is the third course in profit; and the land will be left in such order, as to make it, perhaps, the first.

11. That the most unproductive, and in a still greater degree, the more unprofitable courses, are those in which turnips, cabbages, and potatoes most frequently occur.

12. That on such new land, oats are the best white grain that can be sown, as they yield very extraordinary and valuable crops.

The same intelligent cultivator, consequently, recommends the following course, which is calculated to prove the most profitable:—

1. Beans.
2. Oats.
3. Beans.
4. Oats.
5. Beans.
6. Oats.
7. Clover.
8. Beans.
9. Wheat.

The profit of beans in every rotation, by which the soil is not exhausted, is decisive; and oats are far more productive than either barley or wheat, while the old turf is decaying; because clover will revive the fertility which beans in the eighth year will not lessen, and wheat cannot fail, after these two successive ameliorating crops, to yield a plentiful harvest. In justice to Mr. Young, we shall observe that he proposes such a rotation only for new land, as there are circumstances that would render it inapplicable to other fields. The effects of SPADE HUSBANDRY, with reference to the amount and value of crops will be examined under that article.

CROSIER, in *astronomy*; four stars in the southern hemisphere in the form of a cross.

CROSS, in *heraldry*; is defined by Guillim, an ordinary composed of fourfold lines, whereof two are perpendicular, and the other two transverse; for so we must conceive them, though they are not drawn throughout, but meet, by couples, in four right angles near about the fesse-point of the escutcheon. The content of a cross is not always the same, for when it is not charged, it has only the fifth part of the field; but if it be charged, then it must contain the third part thereof. This bearing was bestowed on such as had performed, or, at least, undertaken some service for Christ and the Christian profession; and it is, therefore, held by several authors the most honourable charge in all heraldry. What brought it into such frequent use was the expeditions into the Holy Land, the cross being the ensign of that war. Several of the religious orders also employed the cross as the sole ornament of their banners; and on its passage through the public streets it was considered as incumbent on those who beheld it to make due reverence, as when the "host" was conveyed along.

CROSS, in *architecture*. This peculiar figure has been adopted very generally by the architects in the construction of religious edifices. Architectural antiquaries have two sorts of crosses, the Greek and Latin. The Greek cross has its arms at right angles, and all of equal length, whereas the Latin cross has one of its limbs much longer than the other three. St. Peter's at Rome was originally intended to be of the latter form, but the plan was afterwards changed to that of a Greek cross. The Cathedral of St. Paul's is a Latin cross, with its base spread with a species of second transept, which renders the breadth of the western front much more symmetrical.

This was also a very common species of architectural ornament for decorating cemetries, market places, or commemorating any peculiar event. One example of this species of cross, combining sculp-

ture with masonry, will give a general notion of their character.

Cross, in *surveying*; an instrument consisting of a brass circle, divided into four equal parts, by two lines intersecting each other at the centre; at the extremity of each line there is a sight fixed, standing perpendicularly over the line, with holes below each slit, for the better discovery of distant objects.

Cross-bar Shot are missiles with iron bars crossing through them, sometimes standing out six or eight inches at both sides. They are used at sea for injuring the enemy's rigging, and in sieges, for destroying the palisades in the covert-way, ditches, &c.

Cross-Bow; formerly a very common weapon for shooting, but not long used in war after the invention of fire-arms. It is a strong wooden or steel bow, fixed to a stock, stretched by the spanner, and shot off by the trigger fixed to the stock. All kinds of weapons, in which the bow was fastened to the stock, were called *cross-bows*, some of which were attached to carriages, and drawn by horses. There was a small kind, from which were shot little balls. To the larger sort were attached instruments for bending the bow. There are some societies still existing in Germany, who exercise with the cross-bow.

Cross Staff; an instrument commonly called the fore-staff, used by seamen to take the meridian altitude of the sun or stars.

Crosselet; a little or diminutive cross, used in heraldry, where the shield is frequently seen covered with crosselets, also fesses and other honourable ordinaries, charged or accompanied with crosselets. Crosses frequently terminate in crosselets.

Cross Fire, in the art of war, is when the lines of fire, from two or more parts of a work, cross one another. It is frequently made use of to prevent an enemy's passing through a defile. The flanks, as well as the faces of two adjoining bastions, afford the means of cross fire, as do also the faces of two adjoining redoubts.

Crotchet, in *music*; one of the notes or characters of time. In length it is equal to half the minim, or double the quaver.

Crotchet, in *printing*; a sort of straight or curved line, always turned up at each extreme; serving to link such articles as are to be read together; and used in analytical tables, &c., for facilitating the divisions and sub-divisions of any subject.

Crotchets are also marks or characters, serving to inclose a word or sentence, which is distinguished from the rest, being generally in this form [ ].

Croton Oil is expressed from the seeds of an East Indian plant, and is one of the most valuable of the late additions to the materia medica. It is so strongly purgative, that one drop is a full dose, and half a drop will sometimes produce a powerful effect. It is also found to produce the same effect when rubbed upon the tongue, or even upon the skin. It is so active, that it should never be used but under the direction of an experienced physician. In the hands of such, it is of great value, as its small bulk and insipid taste render it serviceable in cases in which no common medicine can be used, and its great power makes it operate when other medicines fail. It has been given to the extent of eight or ten drops, in a bad case of *ileus*, which it cured, without producing any bad symptoms. It should, however, be used with great caution.

Croup; a disease that mostly attacks infants, who are suddenly seized with a difficulty of breathing and a crouping noise; it is an inflammation of the mucous membrane of the windpipe, inducing the secretion of a very tenacious, coagulable lymph, which lines the air passages and impedes respiration. The croup does not appear to be contagious. It seems, however, peculiar to some families; and a child, having once been attacked, is very liable to a return. It is confined to young children, and has rarely been known to attack a person arrived at the age of puberty. The application of cold seems to be the general cause which produces this disorder, and therefore it occurs more frequently in the winter and spring than in the other seasons.

It has been said, that it is most prevalent near the sea-coast; but it is frequently met with in inland situations, and particularly those which are marshy. Some days previous to an attack of the disease, the child appears drowsy, inactive, and fretful; the eyes are somewhat suffused and heavy; and there is a cough, which, from the first, has a peculiarly shrill sound; this, in the course of two days, becomes more violent and troublesome, and likewise more shrill. Every fit of coughing agitates the patient very much; the face is flushed and swelled, the eyes are protuberant, a general tremor takes place, and there is a kind of convulsive endeavour to renew respiration at the close of each fit. As the disease advances, a constant difficulty of breathing prevails, and the head is thrown back in the agony of attempting to escape suffocation. There is not only an unusual sound produced by the cough (something between the yelping and barking of dog), but respiration is performed with a hissing noise, as if the windpipe was closed up by some slight, spongy substance. The cough is generally dry; but if any thing is spit up, it has either a purulent appearance, or seems to consist of films resembling portions of a membrane.

Where great nausea and frequent retching prevail, coagulated matter of the same nature is brought up. With these symptoms, there is much thirst, and an uneasy sense of heat over the whole body, a continual inclination to change from place to place, great restlessness, and frequency of the pulse. In an ad-

vanced state of the disease, respiration becomes more stridulous, and is performed with still greater difficulty, being repeated at longer periods, and with greater exertions, until, at last, it ceases entirely.

The croup frequently proves fatal by suffocation, induced either by spasm affecting the glottis, or by a quantity of matter blocking up the air passages; but when it terminates in health, it is by a resolution of the inflammation, by a ceasing of the spasms, and by a free expectoration of the matter exuding from the trachea, or of the crusts formed there. The disease has, in a few instances, terminated fatally within twenty-four hours after its attack; but it more usually happens, that where it proves fatal, it runs on to the fourth or fifth day. Where considerable portions of the membranous films, formed on the surface of the trachea, are thrown up, life is sometimes protracted for a day or two longer than would otherwise have happened.

Dissections of children, who have died of the croup, have mostly shown a preternatural membrane lining the whole internal surface of the upper part of the trachea, which may always be easily separated from the proper membrane. There is likewise usually found a good deal of mucus, with a mixture of pus, in the windpipe and its ramifications. The treatment of this disease must be conducted on a strictly antiphlogistic plan. It will commonly be proper, where the patient is not very young, to begin by taking blood from the arm or the jugular vein; several leeches should be applied along the fore part of the neck. It will then be right to give a nauseating emetic, ipecacuanha with tartarized antimony, or with squill, in divided doses; this may be followed up by cathartics, diaphoretics, digitalis, &c. Large blisters ought to be applied near the affected part, and a discharge kept up by savin cerate, or other stimulant dressing. Mercury, carried speedily to salivation, has in several instances arrested the progress of the disease, when it appeared proceeding to a fatal termination.

As the inflammation is declining, it is very important that free expectoration should take place. This may be promoted by nauseating medicines, by inhaling steam, and by stimulating gargles.

Where there is much wheezing, an occasional emetic may relieve the patient considerably, and, under symptoms of threatening suffocation, the operation of bronchotomy has sometimes saved life. Should fits of spasmodic diffiulty of breathing occur in the latter periods of the disease, opium joined with diaphoretics, would be most likely to do good. Napoleon, on the occasion of the death of his nephew, the Prince of Holland, of this disease, offered a premium of 12,000 francs for the best treatise on the croup. Of eighty-three essays, which were presented to the committee of twelve members assembled for the examination at Paris, in 1811, two were acknowledged as the best, one by Iurine, in Geneva, and the other by Albers, of Bremen, between whom the prize was divided.

Crow, in *mechanics;* a kind of iron lever with a claw at one end, and a sharp point at the other; used for heaving or purchasing great weights.

Crow's Feet, in the *military art;* machines of iron, having four points, each about three or four inches long, so made, that whatever way they fall there is still a point up: they are thrown upon breaches, or in passes were the enemy's cavalry are to march.

Crown. In the early ages, when men were fond of expressing all their feelings by outward signs, a wreath of flowers or leaves was naturally one of the first emblems of honour or of joy. Such was the ornament of the priest in the performance of sacrifice, of the hero on his return from victory, of the bride at her nuptials, and of the guests at a feast. The ancient mythology, which gave every thing a distinct beginning and a poetical origin, ascribes the invention of wreaths to Prometheus, who imitated, with flowers, the fetters which he had borne for his love to mankind, whom he had created. According to Pliny, wreaths were first made of ivy, and Bacchus first wore them. In process of time, they were made of very different materials. Those worn by the Greeks at feasts in honour of a divinity, were made of the flowers of the plant consecrated to the god. Wreaths of roses afterwards became very common. In some cases, wreaths were even made of wool. Wreaths of ivy and amethyst were worn, by the Greeks, on the head, neck, and breast, at entertainments, with a view to prevent drunkenness. Mnesitheus and Callimachus, two Greek physicians, wrote entire books on wreaths, and their medical virtues. Corpses were covered with wreaths and green branches. Lovers adorned with wreaths and flowers the doors of their mistresses, and even captives, who were to be sold as slaves, wore wreaths; hence the phrase *sub corona venire* or *vendere.* The beasts sacrificed to the gods were also crowned. Wreaths, in process of time, were made of metal, in imitation of flowers, or of the fillet which the priest wore round his head when he sacrificed, which was called *διάδημα.* This attribute of distinction was early adopted by the kings, when they united in their persons the temporal and spiritual power. Among the various crowns and wreaths in use among the Greeks and Romans were the following:

Corona agonothetarum; the reward of the victor in the great gymnastic games.

Corona aurea (the golden crown); the reward of remarkable bravery.

Corona castrensis; given to him who first entered the camp of the enemy.

Corona civica; one of the highest military rewards. It was given to him who had saved the life of a citizen.

Corona convivalis; the wreath worn at feasts.

Corona muralis; given by the general to the soldier who first scaled the enemy's wall.

Corona natalitia; a wreath which parents hung up before the door at the birth of a child. It was made of olive branches if the child was a boy, and of wool if a girl.

Corona navalis; the next in rank after the civic crown, was given to him who first boarded and took an enemy's vessel.

Corona nuptialis; a crown or wreath worn by brides. The bridegroom, also, and his relations, on the day of the wedding, adorned themselves with wreaths. At first, the *corona nuptialis* was of flowers; afterwards of gold or silver and precious stones.

Corona obsidionalis; a reward given to him who delivered a besieged town, or a blockaded army. It was one of the highest military honours, and very seldom obtained. It was made of grass; if possible of such as grew on the delivered place.

Corona triumphalis; a wreath of laurel which was given, by the army, to the *imperator.* He wore it on his head at the celebration of his triumph. Another

crown of gold, the material of which (*coronarium aurum*) was furnished by the conquered cities, was carried over the head of the general. The wreaths, conferred at the great games of Greece, were of different kinds; at the Olympic games, of wild olive; at the Pythian games, of laurel; at the Nemean games, first of olive, then of parsley; at the Isthmian games, a wreath of pine leaves, afterwards of parsley; subsequently pine leaves were resumed.

In the middle ages, crowns became exclusively appropriated to the royal and imperial dignity; the coronets of nobles were only borne in their coats of arms. From the Jewish king being called, in the Scriptures, *the anointed of the Lord*, a kind of religious mystery and awe became attached to crowned heads, which, in most countries, continues to the present day, though history has shown us abundantly that crowns often cover the heads of very weak or very wicked individuals, and that there is no great mystery about their origin; some having been obtained by purchase, some by crime, some by grants from a more powerful prince, some by contract, some by choice, but, on the whole, comparatively few in an honest way. The iron crown of Lombardy, preserved at Monza, in the territory of Milan, is a golden crown set with precious stones, with which in former times the Lombard kings were crowned, and at a later period, the Roman-German emperors, when they wished to manifest their claims as kings of Lombardy. An iron circle, made, according to the legend, out of a nail of Christ's cross, which is fixed inside, gave rise to the name. Agilulf, king of Lombardy, was the first person crowned with it (in 590). Charlemagne was crowned with it in 774. Napoleon put it on his head in 1805, and established the order of the iron crown. In 1815, when Austria established the Lombardo-Venetian kingdom, the emperor admitted the order of the iron crown among those of the Austrian empire.—*Crown* is used, figuratively, for the royal power, in contradistinction either to the person of the monarch, or to the body of the nation, with its representatives, interests, &c. Thus, in modern times, the word *crown* is used, on the European continent, to express the rights and prerogatives of the monarch considered as a part of the state, which includes all powers—the legislative, judicial, &c. Thus the crown domains are distinguished from the state or national domains. In France, a difference is even made between the crown domains and the private domains of the king; the former are inalienable, and belong to the reigning monarch, whilst the second may be treated like any other private property. The distinction between crown and state, of course, does not exist in perfectly arbitrary governments.—*Crown-officers* are certain officers at the courts of European sovereigns. Formerly, when the different branches of government were not accurately defined, they were often, or generally, also state officers, as in the old German empire, and still in Hungary. The offices were generally hereditary; but, of late years, they are almost exclusively attached to the court; the title, in a few cases, being connected with military dignities, as for instance, in France, where civil and military grand officers of the crown have always existed.

Crown, in an ecclesiatical sense, is used for the tonsure, the shaven spot on the head of the Roman Catholic priests, where they received the ointment of consecration. See TONSURE.

CROWN, in *architecture*, denotes the uppermost member of the cornice.

CROWN, in *commerce*; a coin, used in every part of the world, of about the same relative value. It rarely exceeds five shillings and sixpence.

CROWN, in *heraldry*, is used for the representation of that ornament, in the mantling of an armory, to express the dignity of the person who bears it. The crown here is of more antiquity even than the helmet; and it was used as a symbol of victory and triumph.

CROWN GLASS, the best kind of window-glass, the hardest and most colourless, is made almost entirely of sand and alkali and a little lime, without lead or any metallic oxide, except a very small quantity of manganese, and sometimes of cobalt. Crown glass is used, in connection with flint glass, for dioptric instruments, in order to destroy the disagreeable effect of the aberration of colours. Both kinds of glass are now made, in the highest perfection, in Benedictbeurn, where Reichenbach's famous manufactory of optical instruments is situated.

CROWTH, or CRUTH; a musical instrument, formerly much in use in Wales, somewhat like the violin. It has six strings, supported by a bridge, standing in an oblique direction with respect to the strings, and is performed with a bow. Of these strings, which are six in number, the first four are conducted from the tail-piece down the finger board; but the fifth and sixth, which are about an inch longer than the others, branch from them laterally, and range about the distance of an inch from the neck.

CRUCIBLE. When solid substances are to be exposed to intense heat to fuse them, or to favour their mutual chemical actions, the vessels, generally employed, at least for experimental purposes, are called crucibles. They are usually of the form of a short truncated inverted cone; some are triangular. Crucibles are made of different materials, according to the purposes for which they are to be used. A crucible ought to support the strongest heat without melting; it ought to resist the attacks of all such agents as are exposed to heat in vessels of this kind.

The Hessian crucibles are composed of sand and clay; they will support an intense heat for many hours, without softening or melting; but they are disposed to crack when suddenly heated or cooled. This inconvenience may be, on many occasions, avoided by using a double crucible, and filling up the interstice with sand, or by covering the crucible with a lute of clay and sand, by which means the heat is transmitted more gradually and equally. Those which give a clear sound when struck, and are of an uniform thickness, and have a reddish-brown colour, without black spots, are reckoned the best. They are sold in nests or sets.

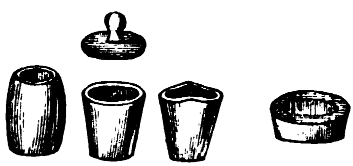
Wedgwood's crucibles, made of porcelain clay, are very excellent for all experimental purposes in the small way. They are very smooth within, and stand a strong heat. They should be coated with fire-lute before they are exposed to the action of a very intense heat.

The black lead crucibles, formed of clay and plumbago, are very durable, resist sudden changes of temperature, and may be repeatedly used; but they are destroyed when certain substances are melted in

them, and suffer a partial injury when exposed red hot to a current of air. They are also very smooth within, so that the melted matters, when poured out, do not adhere to the inside. They are totally unfit for the fusion of alkaline and saline matters, and answer best for metals and metallic substances. They may be used more than once.

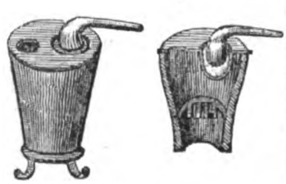
Silver crucibles (of perfectly pure silver) are particularly useful in analytical operations, for the fusion of bodies with alkalies. The utmost degree of heat they can bear is a moderate redness.

Platina crucibles, on account of the infusibility of the metal by the heat of the chemical furnaces, and its perfect unalterability by most agents, render the greatest service in the laboratory. They should always be put into a common crucible to defend them from the direct action of the coals, the slack of which affixes itself to the sides and bottom with so much obstinacy, that it cannot be detached without risk of injury to the vessel. A series of variously formed crucibles are shown beneath.



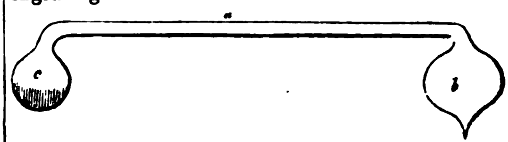
Iron crucibles resist heat extremely well; but the air, aided by the action of the fire, oxidizes them very speedily, and saline matters readily act upon them; even earths become coloured in iron crucibles, so that they cannot be employed for fusion, except in a very few cases

Crucible Furnace. This furnace is made of a common black lead crucible, from twelve to fifteen inches high, perforated at the bottom, and supported by a tripod stand. It is covered with an iron plate, into which two holes are cut; the larger hole admits the sand pot, for distillation with a retort. The fuel is put through the smaller hole. The grate rests on three notches, cut at equal distances on the inside of the body of the furnace. These furnaces serve only for moderate heats. This cheap and simple furnace admits of a variety of useful adaptations, besides those exhibited in the figure, in which we give both a section and general view. Either charcoal or coak may be employed.



Cruor, in *medicine;* the red part of the blood.

Cryophorus; a simple contrivance introduced by Dr. Wollaston, for exhibiting the degree of cold produced by evaporation. To construct the cryophorus, let a tube, having its internal diameter about one-fourth of an inch be taken, and at one extremity let an oblong cavity be formed; at the other extremity, let a ball be blown, into which, prior to closing the cavity, after producing a vacuum (in the manner practised when a thermometer is formed), let a small quantity of water be introduced. The tube between the balls, usually about twelve or fifteen inches in length, is bent, as represented in the engraving, for the purpose of keeping the water in the ball, whilst it is placed in its erect position. It will at once be understood, that all the internal space is occupied by aqueous vapour, produced at the ordinary temperature from the water, on account of the exclusion of air. In employing this apparatus, therefore, for the purpose of freezing the water in one end, it is only necessary to immerse the opposite extremity in any of the freezing mixtures—say, for example, muriate of lime and pounded ice—and the condensation of vapour will be so rapid as to produce a vacuum; which being quickly supplied with fresh vapour, will occasion an abstraction of caloric so constant and considerable from the water in the ball, as very soon to render it solid, even at the distance of two or three feet from the freezing mixture. The tube with its balls, *b* and *c*, are represented in the engraving beneath.



This experiment may be rendered still more striking, and still more illustrative of the refrigerating power of evaporation, by adopting the modification of Dr. Marcet. The empty portion, instead of being surrounded by any of the cooling mixtures above alluded to, is to be covered with flannel, which is afterwards to be moistened with water. This part of the apparatus is to be inclosed in the receiver of an air-pump, within which a shallow vessel, containing strong sulphuric acid, is placed. When the receiver is exhausted, the evaporation from the moistened surface produces so much cold as to condense the vapour within the apparatus; which being continually destroyed by this refrigeration, the water in the ball, as in the more simple experiment, is quickly frozen. The use of the acid in the small vessel will be easily understood, when it is recollected that for the more rapid evaporation it is requisite that the receiver should be constantly emptied of the vapour which it contains, and likewise, that water, either in its liquid or gaseous state, is very rapidly absorbed by concentrated sulphuric acid.

Crypt, in *architecture;* a hollow place or vault constructed under ground. The tombs of the Christian martyrs, also, were so called, where the early Christians met to perform their devotions, for fear of persecution. Hence *crypt* came to signify a church under ground, or the lower story, like that of St. Paul's, London, Lastingham Priory, and many of the ancient ecclesiastical edifices of England, Germany, and France. When crypts are on a large scale, like those of Rome, Naples, and Paris, they are then called *catacombs.*

Cryptography; the art of transmitting secret information by means of writing, which is intended to be illegible, except by the person for whom it is destined. The ancients sometimes shaved the head of a slave, and wrote upon the skin with some indelible colouring matter, and then sent him, after his hair had grown again, to the place of his destination. This is not, however, properly secret writing, but only a concealment of writing. Another sort, which corresponds better with the name, is the following, used by the ancients. They took a small stick, and wound around it bark, or papyrus, upon

which they wrote. The bark was then unrolled, and sent to the correspondent, who was furnished with a stick of the same size. He wound the bark again, round this, and thus was enabled to read what had been written.

This mode of concealment is evidently very imperfect. Cryptography properly consists in writing with signs, which are legible only to him for whom the writing is intended, or who has a key, or explanation of the signs. The most simple method is to choose for every letter of the alphabet some sign, or only another letter. But this sort of cryptography (*chiffre*) is also easy to be deciphered without a key. Hence many illusions are used. No separation is made between the words, or signs of no meaning are inserted among those of real meaning. Various keys, likewise, are used, according to rules before agreed upon. By this means, the deciphering of the writing becomes difficult for a third person, not initiated; but it is likewise extremely troublesome for the correspondents themselves; and a slight mistake often makes it illegible, even by them.

Another mode of communicating intelligence secretly, viz. to agree upon some printed book, and mark the words out, is also troublesome, and not at all safe. The method of concealing the words which are to convey the information intended in matter of a very different character, in a long letter, which the correspondent is enabled to read, by applying a paper to it, with holes corresponding to the places of the significant words, is attended with many disadvantages: the paper may be lost; the repetition of certain words may lead to discovery; and the difficulty of connecting the important with the unimportant matter, so as to give the whole the appearance of an ordinary letter, is considerable. If this is effected, however, this mode has the advantage of concealing the fact that any secrecy is intended.

Writing with sympathetic ink, or milk, lemon juice, &c., is unsafe, because the agents to make the letters visible are too generally known. Hence the *chiffré quarre*, or *chiffre indéchiffrable*, so called, has come very much into use, because it is easily applied, difficult to be deciphered, and the key may be preserved in the memory merely, and easily changed. It consists of a table, in which the letters of the alphabet, or any other signs agreed upon, are arranged under one another, thus:—

z	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z
a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a
b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b
c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c
d	e	f	g	h	i	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d
e	f	g	h	i	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e
f	g	h	i	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f
g	h	i	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g
h	i	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h
i	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i
k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	k
l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	k	l
m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	k	l	m
n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	k	l	m	n
o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	k	l	m	n	o
p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p
q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q
r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r
s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s
t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s	t
u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s	t	u
v	w	x	y	z	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s	t	u	v
w	x	y	z	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s	t	u	v	w
x	y	z	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s	t	u	v	w	x
y	z	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y
z	a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z

Any word is now taken for a key; *Paris*, for example. This is a short word, and, for the sake of secrecy, it would be well to choose for the key, some one or more words less striking. Suppose we wish to write in this cipher, with this key, the phrase "We lost a battle;" we must write *Paris* over the phrase, repeating it as often as is necessary, thus:—

P a r i s P a r i s P a r
We lost a battle.

We now take, as a cipher for *w*, the letter which we find in the square opposite *w* in the left marginal column, and under *p* on the top, which is *m*. Instead of *e*, we take the letter opposite *e*, and under *a*, which is *f*; for *l*, the letter opposite *l*, and under *r*, and so on.

Proceeding thus, we should obtain the following series of letters:—

mfcxlibtkmimw

The person who receives the epistle writes the key over the letters; as,

P a r i s P a r i s P a r
m f c x l i b t k m i m w

He now goes down in the perpendicular line, at the top of which is *p*, until he meets *m*, opposite to which, in the left marginal column, he finds *w*. Next, going in the line of *a* down to *f*, he finds on the left *e*.—In the same way, *r* gives *l*, *i* gives *o*, and so on. Or you may reverse the process; begin with *p*, in the left marginal column, and look along horizontally till you find *m*, over which, in the top line, you will find *w*. It is easily seen, that the same letter is not always designated by the same cypher; thus, *e* and *a* occur twice in the phrase selected, and they are designated respectively by the cyphers *f* and *w*, *b* and *k*. Thus the possibility of finding out the secret writing is almost excluded. The key may be changed from time to time, and a different key may be used with each correspondent. The utmost accuracy is necessary, because one character, accidentally omitted, changes the whole cypher. The correspondent, however, may ascertain this with considerable trouble.

Crystallography. Hauy has succeeded in developing a theory of crystals, so far as to show, that in every crystallized substance, whatever may be the difference of figure, which may arise from modifying circumstances, there is in all its crystals a primitive form, the nucleus, as it were, of the crystal; invariable in each substance, and by various modifications, which he points out, giving rise to the numerous secondary, or actually existing forms.

The fact which led to these views, is, that crystals can be mechanically divided only in certain directions, so as to afford smooth surfaces,—a fact long known by those who work on gems. Suppose a crystal of calcareous spar, a regular hexaedral prism, represented in the plates to Crystallography, *fig.* 5 and 6 [the previous elementary figures will be illustrated in another place], if we endeavour to divide it parallel to the edges which form the outlines of the basis of the prism, we shall find that three of these edges taken alternately, as the upper extremity of the edges *l f*, *d c*, *b m*, readily yield to this division by a knife struck in the proper direction; but that the other three, those which are intermediate, *f d*, *c b*, and *m l*, cannot be divided in a similar manner; and if broken by a greater force, the fracture, instead of being polished like the others, is rugged and uneven. If we repeat the experiments at the under extremity of the prism, we shall find here also that segments of three only of the edges can be detached; but these edges, instead of being the corresponding one with those divisible at the upper extremity, that is, *l f*, *d c*, *b m*, are the intermediate ones, *f d*, *c b*, and *m l*.

The six divisions compose so many trapeziums. Three of these are represented in *fig.* 6, namely, the two which cut off the edges *l f*, *c d*, represented by the dotted lines *p p*, *o o*, and *a a*, *k k*, and that which cuts off the inferior edge *d f*, and which is marked by the dotted lines *n n*, *i i*.

Each of these trapeziums will have a smoothness and lustre, from which it can be perceived that it coincides with one of the natural joinings, the assembling of which forms the prism. The prism cannot be divided in any other directions than these. But if the division be continued parallel to the first segments, it necessarily happens, that on one hand, the surfaces of the bases of the prism become narrower; and that, on the other hand, the heights of the sides diminish; and at the point at which continuing the section, the bases disappear, the prism will be changed into a dodecaedron, with pentagonal faces (*fig.* 7); six of which, *o o i*, O *e*, *o* I *k i i*, &c., are the remains of the sides of the prism, and the other six, E A I *o o*, O A K *i i*, &c., are the immediate results of the mechanical division.

In this, and the two succeeding figures, the hexaedral prism, which circumscribes the solid extracted from it in the division, is still represented to show better the progress of the operation.

Beyond this point, the planes at the extremity preserve their figure and dimensions, while the lateral planes continue to diminish in height, until the points *o*, *k*, of the pentagon *o*, I, *k*, *i i*, coinciding with the points *i*, *i*, and also have the other points similarly situated, having a like coincidence, each pentagon is reduced to a single triangle, as represented in *fig.* 8.

Lastly, by continuing the sections, the triangles are made to disappear; so that there remains no vestige of the surface of the original prism; but in place of it we have the obtuse rhomboid E A I O (*fig.* 9), which is therefore the nucleus or primitive form.

This discovery of the method of dividing a crystal was made by Hauy, in examining a crystal of calcareous spar, which had been detached from a group of which it formed a part. He observed that the fracture had happened at one of the edges of the base of the prism, and that its surface was perfectly smooth and regular. Attempting to detach a segment in a similar direction from the contiguous edge, he could not succeed, but the one next to it was easily divided; and proceeding in this manner, he was able to effect the mechanical division of the crystal in the manner already explained. Struck with the important result of the experiment, he applied the same method to other crystalline forms of the same substance, and obtained from them the same result; the crystal, whatever was its figure, being by this mechanical division converted into a rhomb. Thus, in the dodecaedron, composed of two six-sided pyramids joined by the base, the primitive form may be obtained at once by making a first section, on the edges E O, O I, *fig.* 10; a second, on the edges I K, G K; a third, on G H, E H; a fourth, on O I, I K; a fifth, on G K, G H; and, lastly, a sixth, on E H, E O; and the result is, that these edges become the same with the lateral edges of the primitive form, as may be perceived from mere inspection of *fig.* 11, which represents this primitive form described in the dodecaedron. He then applied it to other crystalline substances, and found, that from these also, by discovering the joints by which the laminæ composing the crystals were united, a certain primitive form might be extracted. That of fluor-spar is an octaedron; and that of the heavy-spar, a prism with rhomboidal bases; of corundum, a rhomboid somewhat acute; of beryl, a hexaedral prism; and of the Elba iron-ore, a cube. Each of these forms is constant with regard to the species, and is that from which all the forms of the varieties, often extremely numerous, are derived. The latter are denominated by Hauy secondary forms. Sometimes, though rarely, the primitive and secondary forms are the same. It is not every crystallized substance, however, that admits of this mechanical analysis. But, with regard to those that have hitherto refused it, Hauy has remarked, that their surface straited in a certain

Fig. 1.

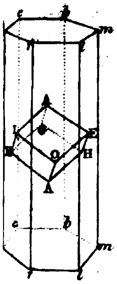


Fig. 2.

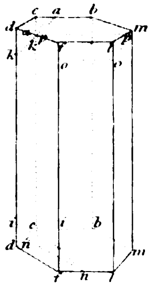
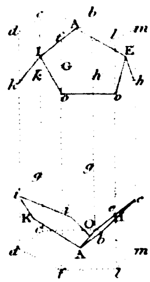


Fig. 3.



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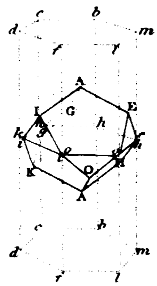
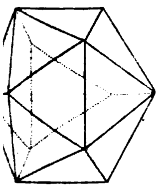


Fig. 5.



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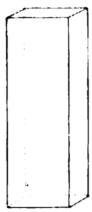


Fig. 7.

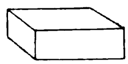


Fig. 8.

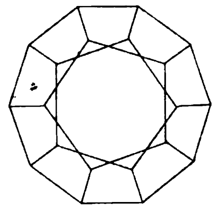


Fig. 9.

Fig. 10.

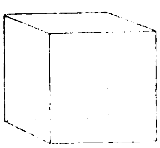


Fig. 11.

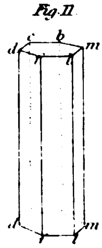


Fig. 12.

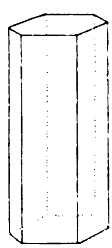


Fig. 13.

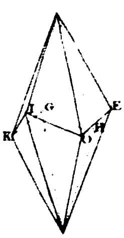


Fig. 14.

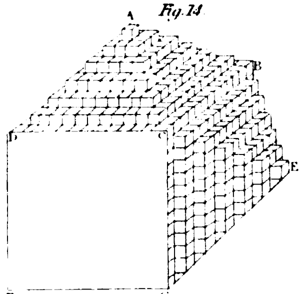


Fig. 15.

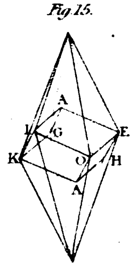


Fig. 16.

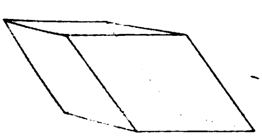


Fig. 17.

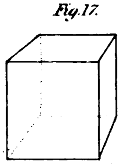


Fig. 18.

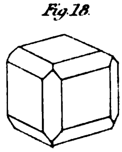
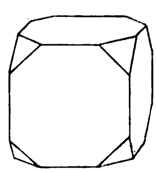


Fig. 19.



London. Published by William Orr, Paternoster Row, May 29th 1833.

direction, or the relation subsisting among the different secondary forms of the same substance, afford indications which lead to the determination, with at least much probability, of their primitive forms.

Such is the process, by which Hauy establishes what he names the "primitive form of crystals," and which he defines, "a solid of a constant form, inserted symmetrically in all the crystals of the same species, and the faces of which observe the directions of the layers, which compose these crystals." The primitive forms hitherto observed, are reduceable to six: the parallelopipedon, which includes the cube, the rhomb, and all the solids which are terminated by six faces parallel two and two; the tetraedron; the octaedron; the regular hexaedral prism; the dodecaedron, with equal and similar rhomboidal planes; and the dodecaedron with triangular planes.

Hauy carries the division of crystals still farther, however, than the primitive forms. The solid which constitutes it, is not the last term of the mechanical analysis; it may always be still farther subdivided parallel to its different faces, and sometimes even in other directions. All the enveloping matter is equally divisible by sections parallel to the faces of the primitive forms; and the only limit to this possible division is that placed by the composition of the substance. The calcareous spar, to take it as an example, may be reduced to a particle beyond which the division cannot be carried without resolving it into its elements, lime and carbonic acid, or at least it may be resolved to a particle beyond which, if its minuteness allowed us to operate upon it, it is demonstrable its figure would not change. To these last particles, the result of the mechanical analysis, Hauy gives the name of integrant particles, and their union constitutes the crystal. Their forms, so far as experiment has been carried, are three: the tetraedron, the simplest of the pyramids; the triangular prism, the simplest of prisms; and the parallelopipedon, the simplest of solids, which have their faces parallel, two and two. There is little doubt that it is between these that the attraction of cohesion is immediately exerted.

The primitive forms, and the figures of the integrant particles, being determined, it remains, to complete the theory of the structure of crystals, to show by what arrangements the secondary forms, in other words, the actually existing crystals, are produced.

The neucleus of the crystal is the symmetrical solid which constitutes its primitive form, arising from the union of the integrant particles, either by their faces or their edges; and the additional matter, which forms the crystal, consists of layers of these particles superadded to that neucleus, and arranged on its faces; and to account for the formation of the crystal under a figure different from that of its primitive form, these layers, as they recede from it, are supposed to decrease, in the space they occupy, from the regular abstraction of one or more ranges of the integrant particles. This decrease may take place in various modes; and according to these, different figures of crystallization will be produced. Thus, to take the simplest example, let us suppose the primitive form is a cube; it is easy to conceive, that on each of its six sides may be reared a series of decreasing layers, or laminæ, composed entirely of cubical particles, each layer diminishing on each of its edges, by one row of the minute cubes of which it consists. The laminæ thus decreasing as they recede from the base on which they rest, until the apex consists of a single particle, it is obvious, that on each side of the cube, a four-sided pyramid will be formed. Two of these are represented, (*fig.* 12.) A B C D, G B C G.

We shall thus have, then, six four-sided pyramids, and of course twenty-four triangles, such as A B C, B C E, C E G, &c. But since the decrease is uniform on all the sides, as from the line B C, to A, and from the same line to E, it must also be uniform from A, to E; it is obvious, therefore, that the side A, B, C, of the one pyramid will be found exactly in the same plane as the side, B C E, of the adjacent; so that the entire surface of these will be the rhomb, A, B, E C. The case must be the same with all the others. The twenty-four triangles will therefore be reduced to twelve rhombs, and the figure will be a dodecaedron, very remote from the primitive form. Now, a crystal of this figure, and having this primitive form, would be resolved into that form, merely by cutting off the six solid angles, by sections, in the direction of the small diagonals of the sides, which go to the formation of these angles. We should thus successively uncover six squares, which will be the faces of the primitive cube.

In explaining the structure of a crystal, although the representation in the figure be such as to show the decrease of the laminæ by rows of particles of such a size as to give a surface uneven, similar to a succession of steps, it is obvious, that if we substitute for this the delicate structure of nature, the number, of laminæ may be so great, and the number of their cubical particles such, that the depression or channel at their edges will be altogether imperceptible to our senses, and the surfaces will appear perfect planes.

Such is an example of the production of a secondary from a primitive form, by a superposition of the laminæ, decreasing according to a certain law. It is obvious, that the laws of decrement may be various, and accordingly the decrements stated by Hauy are of four different kinds: 1. Decrements on the edges, or parallel to the sides, of which the above is an example. 2. Decrements on the angles, that is, decrements of which the lines are parallel to the diagonals of the faces of the primitive form. 3. Intermediate decrements, or those which are parallel to lines situated between the diagonals and edges of that form. 4. Mixed decrements, in which the number of ranges abstracted in breadth or in height give proportions, the two terms of which are beyond unity.

These four laws of decrement explain by the modifications of which they are susceptible, all the varieties of form under which crystals are presented to us. These modifications are reduced to the following: 1. Sometimes the decrements take place on all the edges, or on all the angles. 2. Sometimes, on certain edges, or certain angles only. 3. Sometimes they are uniform by one, two, three ranges, or more. 4. Sometimes the law varies from one edge to another, or from one angle to another. 5. In some cases, the decrements on the edges correspond with the decrements on angles. 6. Sometimes the same edge or the same angle undergoes successively several laws of decrements. And, lastly, there are cases in which the secondary crystal has faces parallel to those of the primitive form, and

which give rise to new modifications, from their combinations with the faces resulting from the decrements.

With such diversity of laws, the number of forms which may exist is immense, and must far exceed what have been observed. Confining the calculation to two of the simplest laws, those which produce subtractions by one or two ranges, it is shown that carbonate of lime is susceptible of 2044 different forms, a number fifty times greater than that of the forms already known; and if decrements of three and four ranges be admitted into the combination, the calculation will give 8,388,604 possible forms of the same substance. And even this number may be much augmented in consequence either of intermediate or mixed decrements being taken into account.

In concluding this sketch of crystallography, which we have extracted from the excellent *System of Chemistry*, by Murray, we have also thought it proper, with him, to give the figures of the more usual forms of crystals and their modifications, with the definitions of Werner, instead of following Hauy in his minute though valuable details.

It is necessary to premise, that the parts of which a crystal is conceived to be composed, are planes, edges, and angles. Planes, according to the usual geometrical definition, are surfaces lying evenly between their boundary lines: they are distinguished into lateral, which are considered as those parts of the surface of the body which are of the greatest extent, and which form its confines towards its smallest extent; and extreme, or terminal, which are those of smallest extent, and form the bounds of the body towards its largest extent. Edges are formed by the junction of two planes under determinate angles; they also are lateral, or those formed by the junction of two lateral planes; and terminal, formed by the junction of two terminal planes, or of a terminal with a lateral plane. Lastly, angles are formed by the junction of two, three, or more planes in one point.

Werner admits even primary figures of crystals which are susceptible of numerous modifications. These figures are,—the icosaedron, the dodecaedron, the hexaedron, which includes the cube, and the rhomb, the prism, the pyramid, the table, and the lens.

1st. The icosaedron, *fig.* 13, is a solid, consisting of twenty equi-lateral triangular planes, united under equal angles. 2d. The dodecaedron, *fig.* 14, or solid of twelve equal or pentagonal faces. 3d. The cube, *fig.* 15, or solid, composed of six quadrilateral planes united at oblique angles. 4th. The rhomb, *fig.* 16, or solid, of six quadrilateral planes, united at oblique angles. 5th. The prism, or solid, of two terminal planes, parallel, equal, and similar, connected by quadrangular lateral planes having one direction; the number of lateral planes may of course be various; the usual forms observed in crystals are, the four-sided rectangular prism, *fig.* 17; and the six-sided equiangular prism, *fig.* 19. 6th. The pyramid, or solid, the base of which is the plane of an indeterminate number of sides, and the sides triangles, the vertices of which meet in one point, forming the summit: the more common varieties of this figure, as forms of crystals, are the three-sided pyramid, or tetraedron, *fig.* 20, and the four-sided pyramid, *fig.* 21. 7th. The table, which, strictly speaking, is nothing but a very compressed prism; it is defined as composed of two parallel lateral planes, and of an indeterminate number of terminal planes, connected with the lateral planes and with each other, and small, compared with the lateral ones; the principal varieties are,—the oblique-angular, or rhomboidal four-sided table, *fig.* 22, the rectangular four-sided table, *fig.* 23, and the six-sided table *fig.* 24. Lastly, the lens, *fig.* 25, a solid, consisting only of two planes, which are curved; of which there are two varieties, one composed of two convex planes, and another composed of a convex and a concave plane. These simple figures are modified by combination, by tunication, by bevelment and by acumination.

The modifications by combination are confined to the pyramids, and these are frequent, two pyramids being joined by the base; the lateral planes of the one being set either directly on the lateral planes of the other, as in the double four-sided pyramid, *fig.* 27; *fig.* 28 is the double six-sided pyramid.

A crystal is said to be truncated, when any or all of its solid angles or edges appear cut off, so that where there would have been an edge or angle, we have a plane, as has already been represented in *fig.* 2 and 3. These two figures represent forms arising from the truncation of the cube: *fig.* 29 shows the cube with the figures and angles and edges: *fig.* 30, the six-sided prism, with truncated terminal edges: *fig.* 31, the same prism, with both the lateral and terminal edges truncated.

A crystal is said to be bevelled when its edges, angles, or terminal planes, are so altered that, instead of an angle, edge, or terminal plane, there appear two smaller converging planes, which terminate in an edge: *fig.* 32 shows the cube with bevelled edges: *fig.* 33, the three-sided pyramid, with bevelled edges: *fig.* 34, the oblique four-sided prism, bevelled on both extremities.

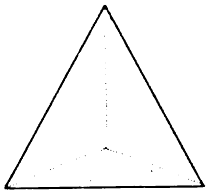
Lastly, the forms of crystals are altered by acumination. This is that kind of alteration in which, in place of the angles or terminal planes of a crystal, there are three or more planes converging and forming a point or edge: *fig.* 35 shows the cube, with angles acuminated by three planes set on the lateral planes: *fig.* 36, the rectangular four-sided prism, acuminated by four planes set on the lateral planes: *fig.* 37, the six-sided prism, acuminated by six planes set on the lateral planes. This kind of modification is often described as consisting of the primary form, with pyramidal terminations.

The forms of crystals, from the preceding modifications, are frequently still more altered, and rendered complicated by being superadded and combined; and by the extent of the modifications, one form frequently passes into another. The figures of crystals are likewise rendered complicated by aggregation, two or more crystals of the same substance being more or less closely united.

The theory of crystallography, introduced by Hauy, does not satisfactorily account for the formation of crystalline bodies; and Dr. Wollaston has very ingeniously proposed to consider the primitive particles as spheres, which, by mutual attraction, have assumed that arrangement which brings them as near as possible to each other. When a number of similar balls are pressed together in the same plane, they form equilateral triangles with each other; and if balls so placed were cemented together, and afterwards broken asunder, the straight lines in which they would be disposed to separate would

CRYSTALLOGRAPHY.

Fig. 20.



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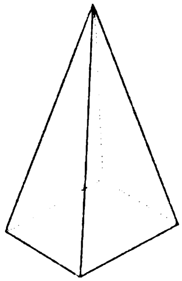

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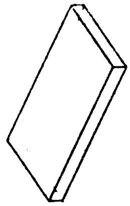

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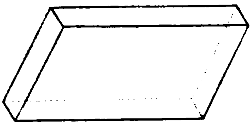

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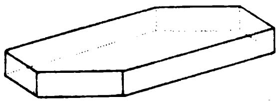
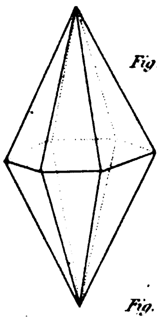


Fig. 25.

Fig. 26.



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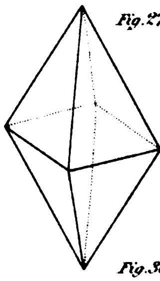

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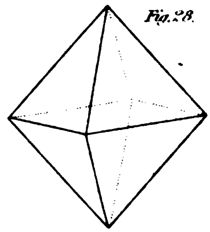

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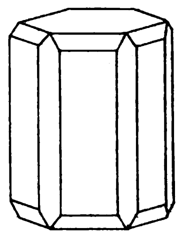

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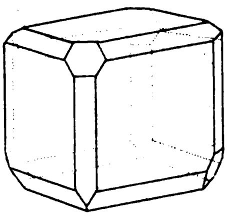

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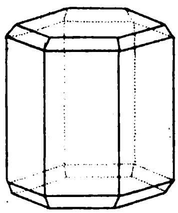

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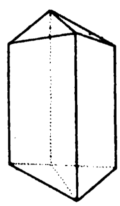


Fig. 32.

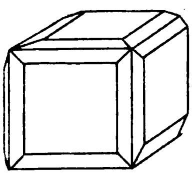


Fig. 33.

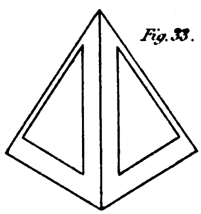


Fig. 37.

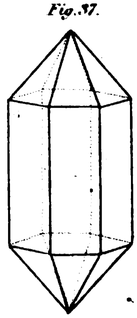


Fig. 36.

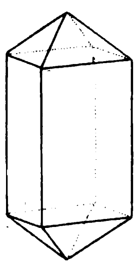
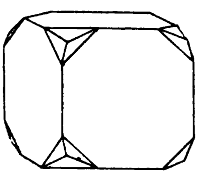
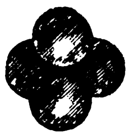


Fig. 35.

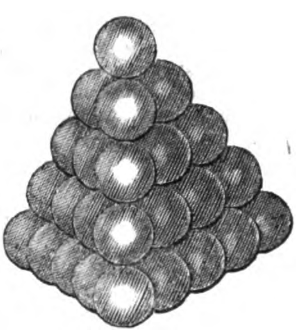


London Published by William Orr, Paternoster Row, March 20, 1833.

form angles of 60° with each other. A single ball placed anywhere on this stratum, as in the accompanying figure, would touch three of the lower balls, and the planes touching their surfaces would include a regular tetraedron.



A square of four balls, with a single ball resting upon the centre of each surface, would form a octoedron; and upon applying two other balls at opposite sides of this octoedron, the group will represent the acute rhomboid.



The accompanying pile represents a series of balls, with triangular faces, the bases of which are constituted of four particles. The tetraedron is confined by four of these similar and equal planes. The subject of crystallization has also especially engaged the attention of Professor Daniell, and his researches have produced some singular confirmations of Dr. Wollastone's hypothesis. If an anamorphus piece of alum be immersed in water, and left quietly to dissolve, at the end of about three weeks the observer will find that it has been unequally acted upon by the fluid; the mass will present the forms of octoedra, and sections of octoedra, as if it were, carved or stamped upon its surface.

This appearance is produced when the attraction of the water for the solid is nearly counterbalanced by its mechanical texture. The crystals formed by this species of dissection are highly curious, from their modifications and relative positions, as the same group presents the primitive form, as well as its truncations and decrements. Other salts yield other figures, and by more complicated chemical action, as of acids, upon carbonate of lime, the metals, &c., analogous results are obtained. Here, then, instead of dividing a crystal by mechanical force, its structure is gradually developed by the process of solution. In these cases two circumstances are particularly remarkable; the crystals are different, and their forms vary with the different faces of the original mass. In one direction we observe octoedra and sections of octoedra; in another, parallelograms of every dimension, modified with some determinate intersections.

If, in either of these positions, we turn the mass upon its axis, the same figure will be perceived at every quadrant of a circle; and, if we suppose the planes continued, they will mutually intersect each other, and various geometrical solids will be constructed. In this way alum alone furnishes octoedrons, tetraedrons cubes, four and eight-sided prisms, either with plain or pyramidal terminations, and rhombic parallelopipedons. It is evident, then, that no theory of crystallization can be admitted which is not founded upon such a disposition of constituent particles, as may furnish all these modifications, by mere abstraction of certain individuals from the congeries, without altering the original relative position of those which remain; and these conditions may be fulfilled by such an arrangement of spherical particles as would arise from the combination of an indefinite number of balls, endued with mutual attraction, and no other geometrical solid is adequate to the purpose; and where bodies afford crystals differing from the octoedral series, an analogous explanation is furnished, by supposing their constituent particles to consist of oblate speroids, whose axes bear different proportions to each other in different substances. Hence we may also conclude, that the internal structure of all crystals is alike, however the external shapes differ. In corroboration of the above hypothesis, we may remark, that the hexaedron is, of all geometrical figures, that which includes the greatest capacity under the least surface. If, therefore, the ultimate particles of crystalline bodies be spheres or spheroids, the greatest possible number in the least space will be included in this form. It is probable that the exterior shape of every crystal is determined by the nucleus first formed by a certain definite number of particles, which, by the power of mutual attraction, overcome the resistance of the medium in which they were suspended, or from which they were separated. This number may vary with the solvent, or other contingent circumstances. Four spherical particles, thus united, would balance each other in a tetraedral group, six in an octoedral group, and each would present particular points of attraction, to which all subsequent deposits would be directed. Now, let us imagine two nuclei formed in the same solution, whose axes run in contrary directions; their increase will consequently be in contrary directions, and each will attract a particular system of particles from the surrounding medium. If these two systems should cross each other in their course, a greater number will be brought within the sphere of mutual reaction at the point of junction, and they ought to arrange themselves in the least possible compass. The facts here answer to the theory. If we select any crystals, having others crossing them nearly at right angles, and separate them, the points of junction invariably present a hexaedral arrangement.

In connection with chemistry, the theory of crystallization opens a new avenue to the science, and frequently enables us to ascertain directly that which, independent of such aids, could only be arrived at by an indirect and circuitous route. We frequently read the chemical nature of substances in the mechanical forms. To the mineralogist an intimate acquaintance with the crystalline forms and modifications of natural bodies is essentially requisite. Indeed, the theory of crystallization may be considered as one of the great supports of that useful branch of natural history; and it is to the indefatigable exertions of Hauy that much of its present perfection is to be referred. In the arts the process of crystallization is turned to a very valuable account, in the separation and purification of a variety of substances. See Brande's *Manual of Chemistry*.

For the more minute details of this subject, particularly as relates to mineralogy, the reader is referred to the NATURAL HISTORY division of this work.

CUBE, in *geometry;* a solid body, consisting of six equal square sides. The solidity of any cube is found by multiplying the superficial area of one of the sides by the height. Cubes are to one another in the triplicate ratio of their diagonals; and a cube is supposed to be generated by the motion of a square

plane along a line equal to one of its sides, and at right angles thereto; whence it follows, that the planes of all sections, parallel to the base, are squares equal thereto, and, consequently, to one another.

Cube, or Cubic Number, in *arithmetic;* that which is produced by the multiplication of a square number by its root; thus 64 is a cube number, and arises by multiplying 16, the square of 4, by the root, 4.

Cube, or Cubic Quantity, in *algebra;* the third power in a series of geometrical proportionals continued; as, *a* is the root, *a a* the square, and *a a a* the cube.

Cube Root of any number or quantity is a number or quantity, which if multiplied into itself, and then again by the product thence arising, gives a product equal to the number or quantity whereof it is the cube root; as, 2 is the cube root of 8, because twice 2 are 4, and twice 4 are 8.

Cubic Foot of any substance; so much of it as is contained in a cube whose side is one foot.

Cubit, in the mensuration of the ancients; a long measure, equal to the length of a man's arm, from the elbow to the tip of the fingers. Doctor Arbuthnot makes the English cubit equal to 18 inches, the Roman cubit equal to 1 foot, 5.406 inches, and the cubit of scripture equal to 1 foot 9.888 inches.

Cucurbit; a glass apparatus used in experimental chemistry. It consists of an oblong vessel with a very wide mouth, on which is ground the head of a common alembic. In the accompanying engraving it is seen to enter a glass flask, which is placed to receive or condense the fluids conveyed by the pipe from the head.

Cuirass; an article of defensive armour, protecting the body both before and behind. Meyrick, in his dissertation on ancient armour, has thus distinguished the cuirasses of different nations:—1. Leathern, with a belt of the same material, worn by the Medes and Persians, before the reign of Cyrus the Great. 2. Plumated or scaled *loricæ* of steel, of which the forepart covered the breast, the front of the thighs, and foreparts of the hands and legs; the posterior part, the back, neck, and whole of the head; both parts being united by *fibulæ* on the sides: these belonged to the Parthian cavalry. 3. Scales made of horses' hoofs, sewed together with the sinews of oxen, were worn by the Sarmatians. 4. That form which was padded with wool, covered with flat rings or square pieces of brass, fastened at the sides, and cut round at the loins. 5. The Etruscans wore plain, scaled, laminated, ringed, or quilted cuishes, with straps depending from them, either of leather solely, or plated with metal; and these straps, as well as the cuirasses, were adopted by the Romans, who termed them *loricæ*.

On the Trajan column, the *loricæ* of the *hastati* and *principes* (the two first ranks) consist of several metal bands wrapped half round the body, and fastened before and behind, over a leathern or quilted tunic. Sometimes the Roman cuirass was enriched with embossed figures. The *loricæ* of the *triarii* (the third rank) were of leather only. Domitian, according to Martial, adopted the Sarmatian cuirass, which he made of the hoofs of boars. The Roman cavalry of the early period did not wear *loricæ;* but even before the *cataphractes* of Constantine (who wore flexible armour of scales and plates and rings, held together by hooks and chains, the *loricæ hamata* of Virgil—*Loricam consertam hamis auroque trilicem,* Æn. iii. 467), we read of horsemen who were *loricati.*—Among the moderns the Anglo Saxons wore leathern cuirasses (*corietæ*), which, towards the end of the ninth century, were formed of hides fitted close to the body, and jagged, or cut into the shape of leaves below. The leathern cuirass, covered with rings, was appropriated to the blood royal, or chiefs of high rank: it was borrowed from the Gauls, and called *mael,* whence our coat of *mail.* The cuirass of the thirteenth century, is shown in the accompanying figure.

The cuirass appears to have been disused in England in the time of Charles II., when bullet-proof silk was introduced. The lance having, of late years, again become an offensive weapon, the cuirass has been revived among the European cavalry. The finest part of Napoleon's cavalry were cuirassiers; and the weight of these heavily-armed soldiers gave great momentum to their charge. The cuirass leaves many vulnerable parts exposed, but, as it protects almost all the trunk, it materially diminishes the chance of wounds, and gives confidence to the soldier. It may hardly be necessary to add, that in some of the best appointed of our cavalry regiments a light cuirass has been adopted.

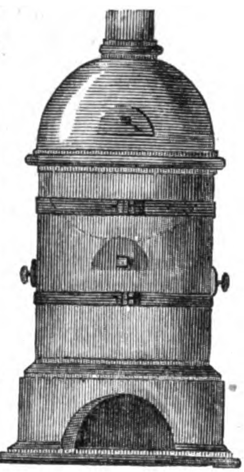
Culm; a species of coal occasionally employed in manufactories. Its *mineralogical* features will be described in the Natural History division of this work.

Culmination, in *astronomy;* the passing of a star through the meridian, because it has at that moment reached the highest point (*culmen*) of its path, with reference to the observer. Hence *culmination* is used,

metaphorically, for the condition of any person or thing arrived at the most brilliant or important point of its progress.

Cupel; a shallow earthen vessel, somewhat resembling a cup, from which it derives its name. It is formed of bone-ashes, and is extremely porous. It is used in assays, to separate the precious metals from their alloys. The process of *cupellation* consists in fusing an alloy of a precious metal, along with a quantity of lead, in a cupel. The lead is extremely susceptible of oxidation, and, at the same time, it promotes the oxidation of other metals, and vitrifies with their oxides. The foreign metals are thus removed; the vitrified matter is absorbed by the cupel, or is driven off by the blast of the bellows, as it collects on the surface; and the precious metal at length remains nearly pure. See Assay.

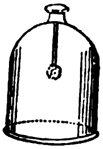
Cupelling Furnace. Under the article Assaying we gave a view of a very complete furnace for cupelling; but it may not be amiss to describe one a good deal used, and of a more portable character.



The accompaying furnace is formed of black lead, and strengthened by hoops of iron. It can be placed on the table, and may be employed for a variety of purposes. The muffle is introduced at the central opening, and the charcoal supplied at the small semi-circular opening in the dome. At the sides may be placed the nozzles of one or more pairs of bellows. This furnace cannot be used for very high temperatures, but is useful to the expermentalist.

Cupola, in *architecture;* a hemispherical roof, often used as the summit of a building. The Italian word *cupola* signifies a hemispherical roof, which covers a circular building, like the Pantheon at Rome, and the round temple at Tivoli. Many of the ancient Roman temples were circular; and the most natural form for a roof for such a building was that of a half globe, or a cup reversed. The invention, or at least the first use, of the cupola belongs to the Romans; and it has never been used with greater effect than by them. The greater part of modern cupolas (unlike those of the ancients, which are mostly hemispherical) are semi-elliptical, cut through their smallest diameter. The ancients seldom had any other opening than a large circle in the centre, called the *eye* of the cupola; while the moderns elevate lanterns on their top, and perforate them with variously formed windows, and other disfigurements. The ancients constructed their cupolas of stone; the moderns of timber, covered with lead or copper. Of cupolas, the finest, without any comparison, ancient or modern, is that of the Rotundo or Pantheon at Rome. Of modern constructions, some of the handsomest are the cupola on the Bank of England, that of St. Peter's at Rome, those of St. Paul's, London, the Hotel des Invalides, and the church of St. Genevieve at Paris, Santa Maria da Fiori at Florence, and St. Sophia at Constantinople.

Cupping; in *surgery,* the operation of applying glasses for the abstraction of blood, after dividing, by means of the scarificator, the vessels of the skin.



The apparatus in ordinary use for cupping consists of a glass bell-formed vessel, which, being inverted upon that part of the body where the punctures have been made by the lancets, an exhaustion is produced within the bell by burning a portion of the air, and the blood immediately flowing into the vacuum, by the pressure of the external air, the desired operation is effected. In removing the glass bell from the swollen part of the flesh, considerable inconvenience arises, and to remedy this is the object of Mr. Kennedy's new glass.

In the upper part of the improved glass bell, shown in the figure, an aperture is made, which is closed by a screwed cap of metal, and rendered air-tight by a collar of leather. By means of this contrivance the burner for consuming the air can be more conveniently introduced, and the glass bell be more correctly fixed than in the old apparatus.

The burning spirit is immediately introduced into the glass bell through the aperture at top; and the cap being screwed down air-tight, a portion of the air within the glass becomes consumed by the flame of the burning spirits. As soon as the glass gets cool, the blood issues from the scarification into the exhausted bell, and when a sufficient quantity has been drawn, the metal cap is unscrewed, and the air re-admitted. The bell containing the blood may now be removed without inconvenience.

Currency. See Money.

Current, a term used to express the present time: thus, the year 1833 is the current year. As applied to commerce, we say, "current coin," for the known and common coin of the country. The "price current" is the known and ordinary price at the present time.

Currents, in the ocean, are continual movements of its waters in a particular direction. In lat. 39° N., lon. 13° 40′ W., we begin to feel the effects of the current which flows from the Azores to the Straits of Gibraltar and the Canaries. Between the tropics, from Senegal to the Caribbean Sea, the general current, and that longest known, flows from east to west. Its average rapidity is from 9 to 10 nautical miles in 40 hours. It is this current which is known by the name of the *equatorial current.* It appears to be caused by the impulse which the trade-winds give to the surface of the water.

In the channel which the Atlantic has hollowed between Guiana and Guinea, under the meridian of 18° or 21° W., from 8° or 9° to 2° or 3° N. lat., where the trade-winds are often interrupted by winds which blow from the south and south-west, the equatorial current is less uniform in its direction. Near the coast of Africa, vessels are often drawn to the south-east, whilst, near the Bay of All Saints and Cape St. Augustine, upon the coast of America, the general direction of the waters is interrupted by a particular current, the effects of which extend from Cape St. Roche to Trinity Island. It flows towards the north-west, at the rate of one foot, or one foot five inches, a second. The equatorial current is felt, although slightly, even beyond the tropic, in latitude 28° N. In the basin of the Atlantic Ocean, 6 or 700 leagues from the coast of Africa, vessels, whose course is from Europe to the West Indies, find

their progress accelerated before they arrive at the torrid zone. Farther north, between the parallels of Teneriffe and Ceuta, in longitude 44° to 46° W., no uniform motion is observed

A zone of 140 leagues separates the equatorial current from that great mass of water flowing to the east, which is distinguished by its elevated temperature, and of which we shall now speak particularly. The equatorial current impels the waters of the Atlantic Ocean towards the Musquito shore and the coast of Honduras, in the Caribbean Sea. The new continent opposes this current: the waters flow to the north-west, and, passing into the Gulf of Mexico, by the strait which is formed by Cape Catoche (Yucatan) and Cape St. Antoine (Cuba), they follow the windings of the American coast to the shallows west of the southern extremity of Florida. Then the current turns again to the north, flowing into the Bahama channel. In the month of May, 1804, A. Von Humboldt observed in it a rapidity of 5 feet a second, although the north wind blew violently. Under the parallel of Cape Canaveral, the current flows to the north-east. Its rapidity is then sometimes five nautical miles an hour. This current, called the *gulf stream*, is known by the elevated temperature of its waters; by their great saltness; by their indigo-blue colour; by the train of sea-weed which covers their surface, and by the heat of the surrounding atmosphere, which is very perceptible in winter. Its rapidity diminishes towards the north, at the same time that its breadth increases. Near the Bahama bank, the breadth is 15 leagues; in lat. 28° 30′ N. it is 17 leagues; and, under the parallel of Charleston, from 40 to 50 leagues. To the east of the port of Boston, and under the meridian of Halifax, the current is almost 80 marine leagues in breadth. There it turns suddenly to the east, and passes the southern extremity of the great bank of Newfoundland.

The waters of this bank have a temperature of from 8° 7′ to 10° centigrade (7° to 8° R., 16° to 18° Fahr.), which offers a striking contrast to the waters of the torrid zone, impelled to the north by the gulf stream, and the temperature of which is from 21° to 22° 5′ (17° to 18° R., 40½° to 83° Fahr.). The waters of the bank are 6° 9′ Fahr. colder than those of the neighbouring ocean, and these are 5° 4′ Fahr. colder than those of the current. They cannot be equalized, because each has a cause of heat or cold which is peculiar to it, and of which the influence is permanent. From the bank of Newfoundland to the Azores, the gulf stream flows to the E. or E.S.E. The waters still preserve there a part of the impulse received in the Strait of Florida. Under the meridian of the islands of Corvo and Flores, the current has a breadth of 160 leagues. In lat. 33°, the equatorial current approaches very near the gulf stream. From the Azores, the current flows towards Gibraltar, the island of Madeira, and the Canaries. South of that island, the current flows to the S.E. and S.S.E., towards the coast of Africa. In lat. 25° and 26°, the current flows first S., then S.W. Cape Blanc appears to influence this direction, and in its latitude the waters mingle with the great current of the tropics.

Blagden, Benjamin Franklin, and Jonathan Williams first made known the elevated temperature of the gulf stream, and the coldness of the shallows, where the lower strata unite with the upper, upon the borders or edges of the bank. A. Von Humboldt collected much information, to enable him to trace, upon his chart of the Atlantic Ocean, the course of this current.

The gulf stream changes its place and direction according to the season. Its force and its direction are modified, in high latitudes, by the variable winds of the temperate zone, and the collection of ice at the north pole. A drop of water of the current would take two years and ten months to return to the place from which it should depart. A boat, not acted on by the wind, would go from the Canaries to the coast of Caracas in 13 months; in 10 months, would make the tour of the Gulf of Mexico; and, in 40 or 50 days, would go from Florida to the bank of Newfoundland. The gulf stream furnished to Christopher Columbus indications of the existence of land to the west. This current had carried upon the Azores the bodies of two men of an unknown race, and pieces of bamboo of an enormous size. In lat 45° or 50°, near Bonnet Flamand, an arm of the gulf stream flows from the S.W. to the N.E., towards the coast of Europe. It deposits, upon the coasts of Ireland and Norway trees and fruits belonging to the torrid zone. Remains of a vessel (the *Tilbury*), burnt at Jamaica, were found on the coast of Scotland. It is likewise this river of the Atlantic which annually throws the fruits of the West Indies upon the shore of Norway.

The causes of currents are very numerous. The waters may be put in motion by an external impulse; by a difference of heat and saltness; by the inequality of evaporation in different latitudes, and by the change in the pressure at different points of the surface of the ocean. The existence of cold strata, which have been met with at great depths in low latitutes, prove the existence of a lower current, which runs from the pole to the equator. It proves, likewise, that saline substances are distributed in the ocean, in a manner not to destroy the effect produced by different temperatures. The polar currents, in the two hemispheres, tend to the east, probably on account of the uniformity of west winds in high latitudes.

It is very probable that there may be, in some places, a double local current; the one above, near the surface of the water, the other at the bottom. Several facts seem to confirm this hypothesis, which was first proved by the celebrated Halley. In the West Indian seas, there are some places where a vessel may moor herself in the midst of a current by dropping a cable, with a sounding lead attached, to a certain known depth. At that depth, there must, unquestionably, be a current contrary to the one at the surface of the water. Similar circumstances have been observed in the Sound. There is reason to believe, that the Mediterranean discharges its waters by an inferior or concealed current. Such a mass of ocean water, flowing constantly from the torrid zone towards the northern pole, and, at any given latitude, heated many degrees above the temperature of the adjacent ocean, must exert great influence on the atmosphere.

Currying is the art of dressing cow-hides, calves'-skins, &c., principally for shoes; and this is done either upon the flesh or the grain. In dressing leather for shoes upon the flesh, the first operation is soaking the leather in water until it is thoroughly wet; then the flesh side is cleaed on a beam about seven or eight inches broad, with a knife of a peculiar construction, to a proper substance. This

is one of the most curious and laborious operations of the whole business of currying. The knife used for this purpose is of a rectangular form, with two handles, one at each end, and a double edge. After the leather is properly shaved, it is thrown into the water again, and scoured upon a board or stone commonly appropriated to that use. Scouring is performed by rubbing the grain or hair side, with a piece of pumice stone, or with some other stone of a good grit. These stones force out of the leather a white substance, called *the bloom*, produced by the oak bark in tanning. The hide or skin is then conveyed to the shade, or drying-place; where the oily substances are applied, termed *stuffing* or *dubbing*. When it is thoroughly dry, an instrument, with teeth on the under side, called a *graining-board*, is first applied to the flesh side, which is called *graining;* then to the grain side, called *bruising*. The whole of this operation is intended to soften the leather to which it is applied. Whitening or paring, succeeds, which is performed with a fine edge to the knife already described, and used in taking off the grease from the flesh. It is then boarded up or grained again, by applying the graining-board first to the grain, and then to the flesh. It is now fit for waxing, which is performed first by colouring. This is effected by rubbing, with a brush dipped in a composition of oil and lamp-black, on the flesh till it be thoroughly black: it is then sized, called *black-sizing*, with a brush or sponge, dried and tallowed; and, when dry, this sort of leather, called *waxed*, or *black on the flesh*, is curried.

The currying leather on the hair, or grain side, called *black on the grain*, is the same with currying on the flesh, until we come to the operation of scouring. Then the first black is applied to it while wet; which black is a solution of the sulphate of iron called *copperas*, in clear water, or in the water in which the skins, as they come from the tanner, have been soaked. This is first put upon the grain after it has been rubbed with a stone; then rubbed over with a brush dipped in stale urine; the skin is then stuffed, and, when dry, it is seasoned, that is, rubbed over with a brush dipped in copperas water, on the grain, till it is perfectly black. After this, the grain is raised with a fine graining-board. When it is thoroughly dry, it is whitened, bruised again, and grained in two or three different ways, and, when oiled upon the grain, with a mixture of oil and tallow, it is finished.

Curtate Distance, in *astronomy;* the distance of a planet from the sun to that point where a perpendicular, let fall from the planet, meets with the ecliptic.

Curtation, in *astronomy*, is the interval between a planet's distance from the sun, and the curtate distance.

Curtin, Curtain, or Courtin, in *fortification*, is that part of the rampart of a place which is betwixt the flanks of two bastions, bordered with a parapet five feet high, behind which the soldiers stand to fire upon the covered-way, and into the moat.

Curve, in *geometry*. The simplest objects are the most difficult to be defined, and mathematicians have never succeeded in giving a definition, satisfactory to themselves, of a line. It is equally difficult to give a satisfactory definition of a curve. Perhaps the simplest explanation of it is, *a line which is not a straight line, nor made up of straight lines*. This definition, however, is deficient in mathematical precision. Since Descartes' application of algebra to geometry, the theory of the curves has received a considerable extention. The study of the curves known to the ancients has become much easier, and new ones have been investigated. Curves form, at present, one of the most interesting and most important subjects of geometry. Such as have not all their parts in the same plane, are called *curves of a double curvature*. The simplest of all curves is the circle. The spiral of Archimedes, the conchoid of Nicomedes, the cissoid of Diocles, the quadratix of Dinostratus, &c., are celebrated curves.

Customs, in *commerce;* the duties or taxes payable upon the importation or exportation of merchandise. Custom duties seem to have existed in every country which had any foreign commerce. The Athenians laid a tax of a *fifth* on the corn and other merchandise imported from foreign countries, and also on several commodities exported from Attica. The *portoria*, or customs, charged on the commodities imported into, and exported from, the different ports in the Roman empire, formed a very ancient and important part of the public revenue. They were imposed, as Tacitus has observed, by the consuls and tribunes, when the spirit of liberty was strong among the people. The rates at which they were charged were fluctuating and various; and little is now known respecting them. In the time of Cicero, a duty of 5 per cent. was, as he himself informs us, levied on corn exported from the ports of Sicily. Under the imperial government, the amount of the *portoria* depended as much on the caprice of the prince as the exigencies of the state. Though sometimes diminished, they were never entirely remitted, and were much more frequently enlarged. Under the Byzantine emperors, they were as high as 12½ per cent.

Customs seem to have existed in England before the Conquest; but the king's claim to them was first established by stat. 3 Edw. I. (A. D. 1274), although the record is not now extant. The duties imposed by this act were on wools, woolfels (sheep-skins), and hides, and were denominated *costuma magna*, in contradistinction to the *costuma parva*, or extraordinary duties paid by aliens, and established by an ordinance of 31 Edw. I. The duties of tonnage and poundage were custom duties; the former being levied on wine by the ton, and the latter being an *ad valorem* duty on all other merchandise. In the 47th year of Edw. III. this latter duty was fixed at 6*d*.; in the 14th of Richard II. it was raised to a shilling, but three years afterwards it was reduced to the original amount. In the 2d year of Henry IV. it was increased to eightpence, and two years afterwards to a shilling. The duties of tonnage and poundage being granted to the crown, were termed subsidies; and, as the latter duty continued for a long period at the rate of one shilling in the pound, or 5 per cent., a subsidy came, in the language of finance, to signify an *ad valorem* duty of 5 per cent. The *new subsidy* imposed by the 9th and 10th of Will. III. was an addition of 5 per cent. to the duties on most imported commodities: other subsidies were levied at subsequent periods. The old or original subsidy was levied according to a book of rates, published in the reign of Charles II.; and a new book was again produced in the reign of George I.

Great confusion prevailed in the collection of the customs, in consequence of the accumulation of duties, and the complicated regulations to which they

gave rise. The embarrassment was greatly increased by special appropriation of each of the different duties on the same article, and the consequent necessity of a separate calculation for each. At the recommendation, however, of the commissioners of accounts, appointed in 1780, alterations were introduced which were productive of the very best effects. The Customs' Consolidation Act, brought in by Mr. Pitt in 1787, abolished the existing duties on all articles, and substituted in their stead one single duty on each article equivalent to the aggregate of the various duties with which it had been previously loaded. This act was founded on no less than 3000 resolutions; and it was the means of introducing a more uniform and simple system into the business of the Custom-house than had before existed. Several similar consolidations have been since effected, the last of which took place in 1825.

The collection of the custom duties is under the superintendence of the Board of Customs, which is not to consist of more than thirteen commissioners; to be reduced to eleven as vacancies occur. The treasury may appoint one commissioner, and two assistant commissioners, to act for Scotland and Ireland.

The increase of the customs' revenue will be apparent from the following view of their amount at the different periods mentioned:—

Year.	Net Revenue.
1590	£50,000
1613	148,075
1660	421,582
1688	781,987
1712	1,315,423
1792	4,407,000
1802	7,415,000
1815	11,360,000
1832	16,795,000

CUTICLE is a thin, pellucid, insensible membrane, of a white colour, that covers and defends the true skin, with which it is connected by the hairs, exhaling and inhaling vessels, and the *rete mucosum*.

CUTIS; the true skin, or a thick, fibrous, vascular, and nervous membrane, that covers the whole external surface of the body, and is the situation of the organ of touch, exhalation, and inhalation.

CUTIS ANSERINA; the rough state the skin is sometimes thrown into from the action of cold or other causes, in which it looks like the skin of the goose.

CUTLASS; a short sword used by seamen. The art of fencing with it is different from that with the small sword or broad sword. A guard over the hand is an advantage. It is, if well understood, a very effectual weapon in close contest: on account of its shortness, it can be handled easily, and yet is long enough to protect a skilful swordsman.

CUTLERY. Though cutlery, in the general sense, comprises all those articles denominated *edge tools*, it is more particularly confined to the manufacture of knives, forks, scissors, penknives, razors, and swords. Damascus was anciently famed for its razors, sabres, and swords. The latter are said to possess all the advantages of flexibility, elasticity, and hardness. These united distinctions are said to have been effected by blending alternate portions of iron and steel in such a manner, that the softness and tenacity of the former could prevent the breaking of the latter.

All those articles of cutlery which do not require a fine polish, and are of low price, are made from blistered steel. Those articles which require the edge to possess great tenacity, at the same time that superior hardness is not required, are made of sheer steel. The finer kinds of cutlery are made from steel which has been in a state of fusion, and which is termed *cast steel*, no other kinds being susceptible of so fine a polish. (See STEEL.) Table knives are mostly made of sheer steel; forks are made almost altogether by the aid of the stamp and appropriate dies; the prongs only are hardened and tempered.

Almost all razors are made of cast steel, the quality of which should be very good, the edge of a razor requiring the combined advantages of great hardness, and tenacity. After the razor blade is forged, it is hardened, by gradually heating it to a bright red heat. and plunging it into cold water. It is tempered by heating it afterwards till a brightened part appears of a straw colour. Though this is generally performed by placing them upon the open fire, it would be more equally effected by sand, or what is still better, in hot oil, or a fusible mixture, consisting of 8 parts of bismuth, 5 of lead, and 3 of tin; a thermometer being placed in the liquid at the time the razors are immersed, for the purpose of indicating the proper temperature, which is about 500° of Fahrenheit. Razors are ground crosswise, upon stones from 4 to 7 inches in diameter, a small stone being necessary to make the sides concave. They are afterwards smoothed and polished.

The handles of high-priced razors are made of ivory and tortoise-shell, but in general they are of polished horn which is preferred on account of its cheapness and durability. The horn is cut into pieces, and placed between two corresponding dies, having a recess of the shape of the handle The dies are previously heated to about 500° of Fahrenheit, and placed with the horn, in a press of such power, that, allowing a man's strength to be 200 pounds, it will be equal to 43,000 pounds. By this process, the horn receives considerable extension. If the horn is not previously black, the handles are dyed black by a bath of logwood and sulphate of iron. The clear horn handles are sometimes stained so as to imitate the tortoise-shell.

The manufacture of penknives is divided into three departments; the first is the forging of the blades, the spring, and the iron scales; the second, the grinding and polishing the blades; and the third, the handling, which consists in fitting up all the parts, and finishing the knife. The blades are made of the best cast steel, and hardened and tempered to about the same degree with that of razors. In grinding, they are made a little more concave on one side than the other: in other respects, they are treated in a similar way to razors. The handles are covered with horn, ivory, and sometimes wood; but the most durable covering is stag-horn. The most general fault in penknives is that of being too soft.

The temper ought to be not higher than a straw colour, as it seldom happens that a penknife is so hard as to snap on the edge.

The beauty and elegance of polished steel is nowhere displayed to more advantage than in the manufacture of the finer kinds of scissors. The steel employed for the more valuable scissors should be cast steel of the choicest qualities: it must possess hardness and uniformity of texture, for the sake of

acquiring a fine polish; and great tenacity when hot, for the purpose of forming the bow or ring of the scissors, which requires to be extended from a solid piece, having a hole previously punched through it. It ought also to be very tenacious when cold, to allow that delicacy of form observed in those scissors termed *ladies' scissors*. After the scissors are forged as near to the same size as the eye of the workman can ascertain, they are paired, and the two sides fitted together. The bows and some other parts are filed to their intended form; the blades are also roughly ground, and the two sides properly adjusted to each other, after being bound together with wire, and hardened up to the bows. They are afterwards heated till they become of a purple colour, which indicates their proper temper.

Almost all the remaining part of the work is performed at the grinding-mill, with the stone, the lap, the polisher, and the brush. The very large scissors are partly of iron and partly of steel, the shanks and bows being of the former. These, as well as those all of steel, which are not hardened all over, cannot be polished: an inferior sort of lustre, however, is given to them by means of a burnisher of hardened polished steel, which is very easily distinguished from the real polish by the irregularity of the surface. By a combination of platinum and some other metals in fine cutlery, it has lately been much improved.

Cutter; a small vessel, furnished with one mast, and rigged as a sloop. Many of these fast-sailing vessels are used by smugglers, and are also employed for the purpose of apprehending them. In the latter case they are called *revenue cutters*.

Cut-Water; the sharp part of the head of a ship below the beak, so called because it cuts or divides the water before it comes to the bow, that it may not come too suddenly to the breadth of the ship, which would retard it.

Cyanogen. This gaseous compound was discovered, in 1815, by Gay Lussac. It may be obtained from dry and pure *cyanuret of mercury*. This substance when heated in a small glass tube to dull redness, becomes black, and a quantity of mercury passes over and condenses in the cold part of the tube: the gas which is at the same time evolved, must be collected over mercury.

It has a penetrating and very peculiar smell, somewhat resembling that of bitter almonds; it burns with a beautiful purple flame. Its specific gravity to hydrogen is 24.4; 100 cubic inches weighing 54.9 grains. Water dissolves 4.5 volumes, and alcohol 23 volumes of this gas. The aqueous solution reddens vegetable blues; and according to Vauquelin is subject to spontaneous decomposition, being gradually converted into carbonic and hydrocyanic acids, ammonia, a peculiar acid, which he calls the *cyanic*, and a brown substance containing carbon; the ammonia saturates the acids, and the carbonaceous compound is deposited. These changes are referable to the mutual re-action of the elements of cyanogen upon those of water. (See Hydrocyanic or Prussic Acid.)

Cycle is used for every uniformly returning succession of the same events. On such successions or cycles of years rests all chronology, particularly the calendar. Our common solar year, determined by the periodical return of the sun to the same point in the ecliptic every body knows, contains 52 weeks and 1 day and leap-year a day more. Consequently, in different years, the same day of the year cannot fall upon the same day of the week; but, as, for example, the year 1814 began with Saturday, 1815 with Sunday, 1816 with Monday; but 1817, because preceded by a leap-year, began not with Tuesday, but with Wednesday.

If we count only common years, it is manifest that, from seven years to seven years, every year would begin again with the same day of the week as the seventh year before; or, to express the same in other words, after seven years, the dominical letter would return in the selfsame order. But as every fourth year, instead of a common year, is a leap-year, this can only take place after 4×7, or 28 years. Such a period of 28 years is called a *solar cycle*, and serves to show the day of the week falling on the first day of January in every year. For this purpose it is only requisite to know with what day of the week a particular year began, and then to prepare a table for the first days of the 27 following years. It is the custom now to fix the beginning of the solar cycle at the ninth year B. C., which was a leap-year, and began with Monday.

If you wish to know what day of the week the new-year's day of any year of our reckoning is, you have only to add nine to the number of the year, and then, after dividing this sum by 28, the quotient gives, of course, the number of complete cycles, and the remainder shows what year of the solar period the given year is, of which the table above mentioned gives the day of the week with which it begins. But this reckoning is only adapted to the Julian calendar. In the Gregorian, it is interrupted by the circumstance that, in 400 years, the last year of the century is three times a common year. Hence this reckoning will not give the day of the week for the first day of the year; but from 1582 (the commencement of the Gregorian calendar) to 1700, for the 11th, from 1700 to 1800 for the 12th, in the 19th century for the 13th day of the year, and so on, from which we must then reckon back to the new-year's day. Hence it is far more convenient to prepare a table for the beginning of a century (for example, for 1801, which began with Thursday), and divide by 28 the number of years from that to the given year, and, with the remainder, seek in the table the day of the week for the first day of the year.

Besides this, another cycle is necessary for the determination of festival days, by the aid of which the feast of Easter, by which all the moveable feasts are regulated, is to be reckoned. Easter depends on the first full moon after the vernal equinox.

The lunar cycle is a period of 19 years, after which the new moon falls again on the same day of the month. As the time from one new moon to another (as astronomy teaches), is about 29½ days, a table of the new moons for 19 years may be very easily prepared. It is only necessary to observe that this lunar cycle always begins with a year, of which the first new moon falls on the first of January, and that this was the case the first year B. C. Divide by 19 the number of the year plus 1, and the remainder will show what year in the lunar period the given year is. The number of the year is called the *golden number*. Besides these two cycles, which are indispensable for the calculations of the calendar, there are some others, several of them known by the name of *periods*.

The Germans make much use of the word *Cyclus* in science, meaning by it any series of events, works,

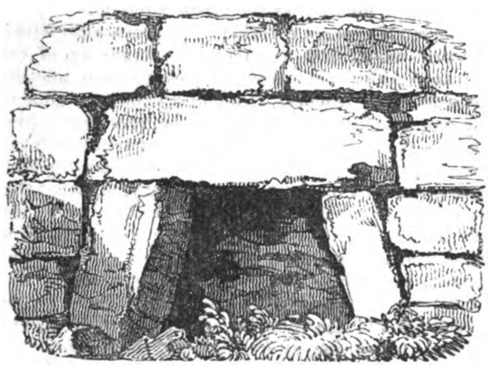
observations, &c., which forms a whole in itself, and reminds us of a circle; thus they speak of the *Cyclus* of works in certain sciences, and *Cyclus* of discoveries by a philosopher, &c., wherever the series forms a well-connected whole.

CYCLOGRAPH, in *practical geometry*; an instrument contrived, as its name imports, for describing the arcs of circles. The simplest kind of cyclograph next to the compasses, is formed of two rulers, so joined together as to be susceptible of standing at any angle between the legs; then by causing the legs or rulers to slide between two pins, while a pencil is fixed at their angular point, the pencil will describe an arc or segment of a circle capable of containing the angle at which the rulers are not.

CYCLOID; the line described by a moving wheel. Imagine a circle which is rolled perpendicularly along a straight line, till the point first at rest is brought to rest again, after an entire revolution. The curve, thus described by this point, is called a *cycloid*, because every point in the circumference of a revolving wheel describes a similar curve. The circle is called the *generating circle*; the line on which it is described, the *base of the cycloid*. The length of the cycloid is always four times the diameter of the generating circle, and its area three times the area of this circle. This line is very important in the higher branches of mechanics.

Imagine a pendulum suspended by a thread, in such a way that, in the swinging of the pendulum between two plates, each of which is bent in the form of a cycloid, the thread rolls and unrolls itself. Then the longest vibrations will be performed in the same time as the shortest, producing an isochronism, and the cycloid is hence called an *isochrone* or *tantochrone*. The name of *brachystochrone* has also been given to the cycloid, because it is the line in which a heavy body, falling in a direction oblique to the horizon, would pass in the shortest time between two points.

CYCLOPEAN WORKS, in *ancient architecture* masonry performed with huge blocks of stone, much of which is to be seen in Sicily, said, by the ignorant, to be the works of an ancient and fabulous gigantic race of people; as Stonehenge is said by the country people to have been built by the devil. Some of these works, called *Cyclopean*, were the walls of Argos and Sicyone. Near to Nauplea, in Argolis, there were caverns which, according to Strabo, were called *Cyclopean*. As servants of Vulcan, the Cyclops were celebrated in mythology and fabulous history for their marvellous works.



A very striking example of Cyclopean architecture exhibited at Stefani, in Sicily, is shown in the engraving, in which a porch is formed of two inclined blocks of eight feet in height, crossed by a third of forty feet in length.

CYDER. See CIDER.

CYLINDER; the name of a geometrical solid, formed by two parallel circular surfaces, called the superior base and the inferior base, and a convex surface terminated by them. There is a distinction between rectangular cylinders and oblique cylinders. In the first case, the axis, that is, the straight line joining the centre of the two opposite bases, must be perpendicular; in the second, the axis must form an angle with the inferior base. The solidity of a cylinder is equal to the product of the base by the altitude. Archimedes found that the solidity of a sphere inscribed in an equilateral cylinder, that is, of a sphere whose diameter is equal to the height, and also to the diameter of the base of the cylinder, is equal to two-thirds of the solidity of the cylinder. The cylinder is one of those figures which are constantly in use for various purposes.

CYLINDROID; a solid resembling the figure of a cylinder; but differing from it as having ellipses for its ends or bases, instead of circles, in the cylinder.

In the cylindroid, the solidity and curve superfices are found the same way as those of the cylinder; viz. by multiplying the circumference of the base by the length or axis; and the area of the base by the altitude, for the solidity.

CYMA, or CYMATIUM, in *architecture*; a member or moulding of the cornice, the profile of which is waved.

CYMBALS, among the ancients; musical instruments consisting of two hollow basins of brass. which emitted a ringing sound when struck together. The brazen instruments which are now used in military music, and have been borrowed by Europeans from the East, seem to have taken their rise from these. The invention of them, according to some writers, must be referred to the worship of Cybele.

DA CAPO, *in music*; an expression written at the end of a movement, to acquaint the performer that he is to return to, and end with the first strain. It is also a call or acclamation to the singer or musician, in theatres or concerts, to repeat a piece which he has just finished.

DACTYLIOTHECA; a collection of engraved gems. The art of engraving gems was nowhere carried to greater perfection than in Greece, where they were worn not only in rings, but in seals, and were much used for other ornamental purposes. The Romans were far behind the Greeks in this art; but they were the first who made collections of precious stones. Scaurus, the son-in-law of Sylla, introduced the custom. Pompey the Great transferred the collection of Mithridates to Rome, and placed it in the capitol. A much larger collection was exhibited by Cæsar in the temple of Venus Genitrix, and, afterwards, under Augustus, by M. Marcellus, in the temple of Apollo Palatinus. In modern times, the princes of Italy vied with each other in collecting these treasures of art.—The family of Gonzaga established the first *dactyliotheca*, and was followed by the family of Este at Modena, that of Farnese, and by Lorenzo de' Medici in Florence. The gems collected by him are marked with *Lor.*, or *Lor. de' M.*, or with *M.* alone. His collection was divided and scattered, but the Medici

established a new one, the foundation of the present *D. Florentina,* the most important existing, as it contains about 4000 gems. Two of the most interesting gems in this collection we have already copied in our mythological articles.

In Rome, collections of no great value were made under Julius II. and Leo X. Piccolomini, a Roman prelate, had the best in that city; and Lucio Odescalchi, afterwards Duke of Bragiani, inherited that of Christina Queen of Sweden. Rome afterwards received the collections of the Vatican (formed more at random than on any concerted plan), of the Barbarini, and of the Strozzi (containing some masterpieces of the art, now in St. Petersburg). The *D. Ludovisia,* belonging to the Prince of Piombino, and that of the Cardinal Borgia at Velletri, famous for its Egyptian gems and *Scarabæi,* are still celebrated.

Naples has beautiful gems in the cabinet at Portici and at Capo di Monte. The prince Piscari formed a collection at Catanea, in Sicily, consisting entirely of gems found in Sicily. In France the first collection was begun by Francis I., but was dispersed in the civil war. In the reign of Louis XIV., Louvois laid the foundation of the present fine collection of antiques in the royal library. The collection of the present king of the French, which he inherited from the Palatinate, is very celebrated. Besides these, there were several private collections of value. The most celebrated in this country are those of the Dukes of Devonshire, Bedford, and Marlborough, and the Earls of Carlisle, and Desborough. Germany also has collections. In the palace of Sans Souci, at Potsdam, near Berlin, several are united, among which is that of Muzel Stosch, rendered famous by the description of Winckelmann. Vienna has a separate cabinet of gems. The collection of Dresden is good. The city library of Leipsic possesses some good gems. The collection at Cashel is extensive, but not very valuable. Munich has some beautiful pieces. There are also many private collections. The cabinet of the king of Holland is valuable.

In the royal palace at Copenhagen, there are some vases inlaid with gems; and Petersburgh has, besides the imperial collection, the foundation of which was that of the engraver Natter, the rich collection of Count Poniatowsky. To multiply elegant and ingenious or remarkable designs on gems, engravings or casts are taken. Thus not only single designs, but all those of the same class, or those of a whole cabinet, are represented by engravings. The impressions of various classes of gems have been collected.

Bellori collected the portraits of philosophers and others; Chifflet, abraxas stones; Gori, gems engraved with stars; Ficoroni, gems with inscriptions; Stosch, gems bearing the names of the artists. Representations of whole collections have been given; as, by Gori, of those contained in the *Museum Florentinum*; by Wicart and Mongez, of those in the gallery of Florence; by Mariette, of the former French collections; by Leblond and Lachaux, of that of the Duke of Orleans; by Eckhel, of that of Vienna. We might also mention the copies of the *Museum d'Odescalchi,* of the cabinets of Gravelle, Stosch, Bossi, and the Duke of Marlborough. But although some of these impressions are very beautiful, the preference ought to be given to the casts. The collections of such casts are also called *dactyliothecæ*; for instance, the *dactyliotheca* of Lippert, consisting of 3000 pieces. Tassie, in London, has executed the largest collection of casts yet known, amounting to 15,000. These are important aids in the study of the branch of antiquities with which they are connected; and many of the finest may now be procured in the streets of the metropolis at the cost of about three shillings for each hundred of casts.

DACTYLIOMANCY; the pretended art of divining by means of rings.

DAIRY; a building appropriated to the purpose of preserving and managing milk, skimming cream, making butter, cheese, &c., with sometimes the addition of pleasure rooms for partaking of the luxuries of the dairy, as syllabubs, cream with fruit, iced creams, &c. See RURAL ECONOMY.

DAL SEGNO. In music, this expression denotes that the singer or player ought to recommence at the former place, where the same mark is put.

DAMASK; an ingeniously manufactured stuff, the ground of which is bright and glossy, with vines, flowers, and figures interwoven. At first, it was made only of silk, but afterwards of linen and woollen, as, for example, damask table-cloth. According to the opinion of some, this kind of weaving was derived from the Babylonians; according to others, invented at a later period, by the inhabitants of Damascus, from which latter place it is thought to have derived its name. The true damasks are of a single colour. If they consist of variegated colours, they are called *ras de Sicile*. The gauze damask also belongs to the silk damask. In modern times, the Italians and Dutch first made damask; and Europe was supplied, as late as the 17th century, from Italy alone, chiefly from Genoa. But the French soon imitated it, and now surpass the Italians. Damask is also brought from India and China, which is very well imitated by the English. At present, damask is made in great quantities in Germany, of three different kinds, Dutch, French, and Italian.

DAMASKEENING, or DAMASKING, the art of inlaying iron or steel with other metals, especially gold and silver, is of great antiquity. It is principally used for sword-blades, guards, cocks of pistols, &c. Herodotus mentions a saucer so ornamented: so, also, were the shields of some of the forces of the Samnites which fought against Rome. It was a favourite manufacture with the ancients. We know not at what time it so flourished at Damascus as to have derived its name from that city.

DAPHNIN; the bitter principle of *Daphne Alpina*. From the alcoholic infusion of the bark of this plant, the resin has been separated by partial evaporation, and the remaining tincture, on being diluted with water and filtered, afforded, on the addition of acetate of lead, a yellow precipitate, from which sulphureted hydrogen disunited the lead, and left the daphnin in small transparent crystals. They are hard, of a grayish colour, a bitter taste; when heated, evaporate in acrid acid vapours; and are sparingly soluble in cold, and but moderately so in boiling water.

DART; a small spear or javelin, much in use among the ancients, and yet seen in many of the more barbarous nations, especially where the use of gunpowder is little known. The Caffrees of South Africa are extremely expert in throwing the dart, as are the aboriginal inhabitants of Australia. The dart in use among the ancients was of two kinds; viz., spear-headed, that is, without barbs; or bearded, like the generality of arrows. The former were often

attached to a long cord, which enabled the thrower to recover his weapon, where it missed the arm, or when it could be withdrawn from a flesh-wound. Most darts have iron heads; but the Americans, particularly in the less frequented tracts of that immense continent, as well as the inhabitants of some parts of Africa, use only a hard wooden staff, sharpened at the point, and a little carbonised by means of fire; others use fish-bones, flints, sea-shells, &c. in their darts, as well as for their arrows. We find the dart to be everywhere very simple, and ordinarily from three to five feet in length.

Datholite, in *mineralogy*. See Natural History Division.

Davit, in a ship; a long beam of timber, used as a crane, whereby to hoist the flukes of the anchor to the top of the bow, without injuring the sides of the vessel as it ascends—an operation which is called, by mariners, *fishing the anchor*.

Day, properly speaking, is the time of a revolution of the earth round its axis (sidereal day, see Sidereal Time); or the time between two passages of the centre of the sun through the same meridian (solar day, see Solar Time)—a time a little differing from the one first mentioned. In common parlance, *day* is opposed to *night*, and signifies the time between sunrise and sunset, or the time during which the sun remains above the horizon. This is called the *natural day*. Thus we have three different days—the natural, the astronomical (reckoned from one culmination to another, or from one moon to another), and the civil day (which is reckoned from midnight to midnight). The 24 hours of the astronomical day are numbered in succession from 1 to 24, whilst the civil day, in most countries, is divided into two portions, of 12 hours each. The first hour, therefore, after midnight, which is one o'clock A. M. of the civil day, makes the 13th hour of the astronomical day, and the first hour of the astronomical day is one o'clock, P. M. of the civil day. The abbreviations P. M. and A. M. (the first signifying *post meridiem*, Latin for *afternoon*; the latter *ante meridiem, forenoon*) are requsite, in consequence of our division of the day into two periods of 12 hours each. In this respect, the mode of numbering the hours from 1 to 24 consecutively has an advantage. If we take a day according to the first definition given of it, its length, of course, is the same throughout the year.

According to the second definition, however, the day, in consequence of the different rapidity of the earth in its orbit, is different at different times, and this difference is uniform throughout the earth; but the time of the natural day is different at the different points of the earth, according to their distance from the equator. The daily apparent revolution of the sun takes place in circles parallel to the equator. If the equator and ecliptic coincided, the circle bounding light and darkness would always divide, not merely the equator, but all its parallels, into two equal parts, and the days and nights would be equal in all the parallels through the year; but at the poles, there would be no night.

Owing to the inclination of the earth's axis to the plane of its orbit (the ecliptic), the parallel of latitude in which the sun appears to move is continually changing; and, therefore, the equator alone (being a great circle) always remains bisected by the circle dividing light from darkness; so that the days and nights here are always equal; while the parallels of latitude, not being great circles, are not equally divided by the circle separating light from darkness, except at the time of the equinox, when the sun is moving in the equator; and, of course, at this time only are the days and nights equal in those parallels.

As you approach the poles, the inequality between the days and nights becomes continually greater, till, at the poles themselves, a day of six months alternates with a night of equal duration. The most distant parallel circles which the sun describes north and south from the equator, are, as is well known, only $23\frac{1}{2}°$ from it. The distance between the polar circles and the poles is the same. Therefore, as a little reflection will show, when the sun is in one of the tropics, all the polar circle in the same hemisphere will be within the illuminated region (because it will be within 90° of the sun) during the whole of a diurnal revolution, while the other polar circle will be in the region of darkness. These circles, therefore, have one day of 24 hours, and one night of the same length, in each year. From the polar circles to the poles, the time of the longest day increases fast, and, in the same measure, the length of the longest night. Notwithstanding the inequality of the periods of light and darkness in the different parts of the earth, each portion of the earth's surface has the sun above its horizon, every year, precisely six months, and below it the same length of time.

Dead-Eye, or Dead Man's Eye; a wooden block, encircled with a rope, or with an iron band, and pierced with three holes through the flat part, in order to receive a rope called the *laniard*, which, corresponding with three holes in another dead-eye, creates a purchase, employed for various uses, but chiefly to extend the shrouds and stays, otherwise called the *standing rigging*.

Dead Reckoning; the judgment or estimation which is made of the place where a ship is situated, without any observation of the heavenly bodies. It is obtained by keeping an account of the distance which the ship has run by the log, and of her course steered by the compass, and by rectifying these data by the usual allowances for drift, lee-way, &c., according to the ship's known trim. This reckoning is, however, always to be corrected as often as any good observation of the sun can be obtained.

Deaf and Dumb. See Dumb.

Deal; a thin kind of fir planks, of great use in carpentry: they are formed by sawing the trunk of a tree into a great many longitudinal divisions, of more or less thickness, according to the purposes they are intended to serve. Deals are rendered much harder by throwing them into salt water as soon as they are sawed, keeping them there three or four days, and afterwards drying them in the air or sun; but neither this nor any other method yet known will preserve them from shrinking. Deals are imported into this country from Christiana, and other parts of Norway; from Dantzic, and other parts of Prussia; from St. Petersburg, Archangel, Narva, Memel, &c. They are sold by the piece or by the standard hundred, or by the long hundred of 120. A standard, or reduced deal, is one inch and a half thick, eleven inches wide, and twelve feet long.

Death, in common language, is opposed to *life*, and considered as the cessation of it. It is only, however, the organic life of the individual which becomes extinct; for neither the mind nor the matter which constituted that individual can perish

That view of nature which considers the whole as pervaded throughout by the breath of life, admits only of changes from one mode of existence to another. This change, which is called *death*, does not take place so quickly as is generally believed. It is usually preceded and caused by disease or the natural decay of old age.

The state called *death* takes place suddenly only when the heart or the brain is injured in certain parts. Probably the brain and the heart are the parts from which, properly speaking, death proceeds; but, as the cessation of their functions is not so obvious as the cessation of the breath, which depends on them, the latter event is generally considered as indicating the moment when death takes place. In the organs of sense and motion, the consequences of death first become apparent; the muscles become stiff; coldness and paleness spread over the whole body; the eye loses its brightness, the flesh its elasticity; yet it is not perfectly safe to conclude, from these circumstances, that death has taken place, in any given case, because experience shows that there may be a state of the body in which all these circumstances may concur, without the extinction of life. This state is called *asphyxia*. The commencement of putrefaction, in ordinary cases, affords the first certain evidence of death. This begins in the bowels and genitals, which swell, become soft and loose, and change colour; the skin, also, begins to change, and becomes red in various places; blisters show themselves; the blood becomes more fluid, and discharges itself from the mouth, nose, eyes, ears, and anus. By degrees, also, the other parts are decomposed, and, last of all, the teeth and bones.

In the beginning of decomposition, azote and ammonia are produced: in the progress of it, hydrogen, compounded with carbon, sulphur, and phosphorus, is the prevailing product, which causes an offensive smell, and the light which is sometimes observed about putrefying bodies. At last, only carbonic acid gas is produced, and the putrefying body then smells like earth newly dug. A fat, greasy earth remains, and a slimy, soap-like substance, which mixes with the ground, and contributes, with the preceding decompositions, to the fertility of it. Even in these remains of organized existence, organic life is not entirely extinct; and they contribute to produce new vegetable and animal structures. Putrefaction is much influenced by external circumstances, particularly air, heat, and water. When the body is protected from the action of such agents, it changes into *adipocire;* but this process requires a much longer time than common putrefaction.

In very dry situations, the body is converted into a mummy, in which state bodies are found in the arid deserts of Africa, and on the mountains in Peru. Some vaults are remarkable for preserving corpses from putrefaction. It is well known to every reader, that particular substances counteract putrefaction; for instance, those used in tanning, and in embalming mummies, and more especially the chlorides.

Death, agony of, is the state which immediately precedes death, and in which life and death are considered as struggling with each other. This state differs according to the cause producing it. Sometimes it is a complete exhaustion; sometimes a violent struggle, and very irregular activity, which, at last, after a short pause, terminates in death.

In some cases, consciousness is extinguished long before death arrives; in other cases, it continues during the whole period, and terminates only with life. The person in this condition has already somewhat the appearance of a corpse; the face is pale and sallow, the eyes are sunken, the skin of the forehead is tense, the nose pointed and white, the ears are relaxed, and the temples fallen in; a clammy sweat covers the forehead and the extremities, the alvine discharges and that of the urine take place involuntarily, the respiration becomes rattling, interrupted, and, at length, ceases entirely. At this moment, death is considered to take place. This state is of very different length; sometimes continuing for minutes only, sometimes for days. When the patient is in this condition, nothing should be attempted but to comfort and soothe him by prayer, by consoling assurances, by directing his attention to his speedy union with departed friends.

As long as the dying person is able to swallow, wine or other cordials may be given from time to time. It is a grateful duty to minister to the sufferings of those we love; and, where there is no hope, these offices have the additional interest that they are the latest we can pay. We have described how the violent struggle preceding death manifests itself, particularly on the human face, that tablet of all expression. After death, however, it not unfrequently happens that the countenance regains its most natural expression, and the saying is common —"How natural, how like himself!" The mind seems for a moment to have regained its influence over what it has so long irradiated, and to shed over the countenance its most beautiful light, to cheer the hearts of the friends who have witnessed the distortion of death, and afford an earnest of its own immortality.

Death, Dance of; an allegorical picture, in which are represented the various figures and appearances of death in the different relations of life, as a dance, where Death takes the lead. The idea of such a dance appears to be originally German, and to belong to poetry. In later times it was used also in England and France, by poets and artists. The French have such a dance (*La Danse Macabre*), derived, it is said, from a poet called Macaber, but little known. A Dance of Death was painted on the walls of the church-yard of the Innocents, at Paris, about the middle of the 15th century, which the chapter of St. Paul's, in London, caused to be copied, to adorn the walls of its monastery. Gabriel Peignot, in the *Recherches sur les Danses des Morts et sur l'Origine des Cartes à jouer*, investigated the origin of the Dance of Death in France, and thus explained the dancing positions of the skeletons: that, according to the relations of old chronicles, those who were attacked by the plague ran from their houses, making violent efforts to restore their rapidly-declining strength by all kinds of morbid movements. Others derive the origin of this representation from the masquerade. These dances are often found painted on the walls of Catholic burial-places. The most remarkable Dance of Death was painted, in fresco, on the walls of the church-yard, in the suburb of St. John, at Basle, which was injured, in early times, by being washed over, and is now entirely destroyed. This piece has been ascribed to the celebrated Hans Holbein; but it has long since been proved that it existed 60 years before his birth. It was painted at

Basle, in the year 1431, by an unknown artist, in commemoration of the plague, which prevailed there at that time; the council was then sitting, and several of its members were carried off by it. It represented Death as summoning to the dance persons of all ranks, from the pope and the emperor down to the beggar, which was explained by edifying rhymes. That piece contained about 60 figures, as large as life. Besides being ascribed to Holbein, as was before stated, it has also been ascribed to a painter named Glauber, but without foundation. Holbein perhaps conceived, from this picture, the idea of his Dance of Death, the original drawings of which are in the cabinet of the Empress of Russia, Catharine II. Some say that Holbein himself made the wood-cuts of it. The latest engravings of this picture of Holbein are in 33 plates, in the *Œuvres de Jean Holbein, par Chr. de Meckel* (1st volume, Basil, 1780). Similar representations were painted, in the 15th century, in other cities of Switzerland. The Dance of Death in St. Mary's Church, at Lubeck, was completed in 1463. On the walls of the church-yard of the Neustadt of Dresden, there is, even at the present time, to be seen a similar Dance of Death. It is now, however, somewhat indistinct and consists of 27 *bassi-relievi* figures, worked on sand-stone, and includes persons of both sexes, and of all ranks. The labour of the sculptor has more merit than the unpoetical rhymes which were afterwards added.

December, the twelfth month of our year, from the Latin *decem* (ten), because, in the Roman year instituted by Romulus, it constituted the tenth month, the year beginning with March. In December, the sun enters the tropic of Capricorn, and passes our winter solstice. This month was under the protection of Vesta.

Decimal Arithmetic; a kind of calculation in which no other fractions are used than tenths, hundreths, thousandths, &c., which are consequently called *decimal fractions*. Joh. Regiomontanus first made use of it in his Tables of the Sines. It affords great facilities in calculation. As, in our system of notation, the values of figures are determined by their places, so that the figure on the left is always of ten times more value than the next at the right hand; so in decimal fractions, which must be considered as an extension of the decimal system, the place of the numerator determines the value of the denominator of the fraction, which need not, therefore, be expressed. The integers are separated from the fractional numbers by a period, so that this period, placed between several numbers, is the characteristic sign of a decimal fraction. For instance, 5.36 is 5 whole numbers, 3 tenths and 6 hundredths, or 36 hundredths; 5.009 is 5 whole numbers and 9 thousandths. If the divisions of money and measures be in a decimal ratio, as is the case with those adopted during the French revolution, the ease of calculation is greatly increased, almost all operations being reduced to addition and subtraction.

Decimal Measure; the division of the unit of measure (whatever it be, as a foot, a rod, &c.) into ten equal parts. The quadrant of a circle has also been divided into ten equal parts. In this case, the tenth part of such a quadrant is called a *decimal degree*. The French mathematicians, however, call the hundreth part of such a quadrant a *decimal degree*, and the hundreth part of such a degree a *decimal minute*.

Decked, in *heraldry*; a term applied to an eagle, or other birds, when their feathers are trimmed at the edges with a small line of another colour.

Declination of a Planetary Body, is its distance from the equinoctial, northward or southward. When the sun is in the equinoctial, he has no declination, and enlightens half the globe from pole to pole. As he increases in north declination, he gradually shines farther over the north pole, and leaves the south pole in darkness. In a similar manner, when he has a south declination, he shines over the south pole, and leaves the north pole in darkness.—23° 28′ is the sun's greatest declination north or south.

Declinator, or Declinatory; an instrument contrived for taking the declinations, inclinations, and reclinations of planes.

Decline; a popular term for almost all chronic diseases, in which the strength and plumpness of the body gradually decline, or decrease, until the patient dies. The term is synonymous with consumption (which see), and is more particularly applied to consumption of the lungs, when the blood ceases to receive a due oxygenating power from the vital principle of the air. Counter-irritants appear to have had the happiest effects, even in the hands of the most ignorant pretenders to the medical art, and, there is little doubt but that, in the hands of a discriminating practitioner, a series of blisters, united to a proper regimen, will accomplish much in all the earliest stages of consumption.

Decoction, in *pharmacy*; a very common and highly useful way of extracting the soluble and efficacious part of many drugs, particularly of barks, woods, and roots, and other substances which contain much inert and insoluble matter. The proportion of the substance boiled in the water seldom, if ever, exceeds an ounce of the former to a pint of the latter, and frequently half or a quarter of an ounce is sufficient.

Decomposition, Chemical, is the resolution of a compound substance into its constituent parts, which are exhibited either separate or in some new combination. The compounds which are spontaneously formed by organic bodies, both vegetable and animal, are of a different nature from those which exist in unorganized matter. They are the peculiar results of vital processes, and neither their structure nor composition can be imitated by art.

During life, the elements of organic bodies are held together by vital affinities, under the influence of which they were originally combined. But no sooner does life cease, than these elements become subject to the laws of inert matter. The original affinities, which had been modified or suspended during life, are brought into operation; the elementary atoms re-act upon each other, new combinations are formed, and the organized structure passes, sooner or later, into decay. The rapidity with which decomposition takes place in organic bodies, depends upon the nature of the particular substance, and upon the circumstances under which it is placed. Temperature, moisture, and the presence of decomposing agents, greatly affect both the period and extent of this process. By regulating or preventing the operation of these causes, the duration of most substances may be prolonged, and many materials are rendered useful, which, if left to themselves, would be perishable and worthless. The preservation of timber, of fibrous

substances, of leather, of food, and of various objects of art, is a subject of the highest importance, and has received, at various times, much attention from scientific experimentalists. See GALVANIC ELECTRICITY, MANURES, and VEGETABLE LIFE.

DECOY, in *military* affairs; a stratagem to carry off the enemy's horses in a foraging party, or from pasture. The word is also used to denote a stratagem employed by a small ship-of-war, to betray a vessel of inferior force into an incautious pursuit till she has drawn her within the range of her cannon. It is usually performed by painting the stern and sides, in such a manner as to disguise the ship, and represent her either much smaller, and of inferior force, or as a friend to the hostile vessel, which she endeavours to ensnare, by assuming the emblems and ornaments of the nation to which the stranger is supposed to belong.

DECREPITATION is the crackling noise, accompanied by a violent exfoliation of their particles, which is made by several salts and earthy compounds, on being suddenly exposed to heat. It appears to be referable to the same cause which occasions the cracking of glass and cast-iron vessels, when they are incautiously heated; viz., the unequal expansion of the *laminæ* which compose them, in consequence of their imperfect power of conducting heat.

DECRESCENDO; an Italian term in music, which denotes the gradual weakening of the sound.

DECUSSATION; a term in geometry, optics, and anatomy, signifying the crossing of two lines, rays, or threads, when they meet in a point, and then go on separately from one another.

DEEP SEA LINE, or DIP SEA LINE, in *nautical* language, a small line used for sounding, when a ship is in very deep water at sea. At the end of this line is a piece of lead called the deep sea lead, at the bottom of which is a coat of white tallow, to bring up stones, gravel, shells, or the like, from the bottom, in order to learn the difference of the ground; which being entered, from time to time, in the seaman's books, by comparing of observations, enables them to guess by the soundings, &c. what coast they are on, though they cannot see the land.

DEFILE; a narrow way, admitting only a few persons abreast. The term is often erroneously confined to mountain passes. As they delay the march of troops, and expose them to the fire of the enemy, they must be avoided if possible, particularly by artillery and waggons.

A defile is defended in different ways. When it is formed by heights (particularly if they are covered with wood), it is advisable to occupy the entrance, and station the troops *en masse* behind: when this is not the case, the best way will be to render the passage as impracticable as possible, and to make a stand behind the outlet of the defile, so that the enemies advancing from it may be checked by an effectual fire, and prevented from developing themselves. A position before the defile, for the purpose of defending it, is only to be thought of when the passage of another division is to be covered. This method may be more or less varied in the defence of bridges. In passing a defile in sight of the enemy, after the usual precautions of patrols, &c., the van-guard must first march rapidly through, and take a position before the outlet, so as to cover the developement of the succeeding masses, the preventing of which will be the object of the enemy. To defile is, therefore, to pass through a narrow passage. To march before any one with a narrow front, that is, *en colonne*, or by files, is also called *defiling*.

DEFENCES, in *heraldry;* the weapons of any beast, as the horns of a stag, the tusks of a wild boar, &c.

DEGREE, in *algebra;* a term applied to equations, to distinguish the highest power of the unknown quantity. Thus, if the index of that power be 3 or 4, the equation is respectively of the 3d or 4th degree.

DEGREE, in *geometry* or *trigonometry*, is the 360th part of the circumference of any circle; every circle being considered as divided into 360 parts, called degrees, which are marked by a small ° near the top of the figure; thus, 45° is 45 degrees. The degree is subdivided into 60 smaller parts, called *minutes;* the minute into 60 others, called *seconds;* the second into 60 *thirds*, &c. Thus 45° 12′ 20″ is 45 degrees, 12 minutes, 20 seconds. The magnitude or quantity of angles is estimated in degrees; for, because of the uniform curvature of a circle in all its parts, equal angles at the centre are subtended by equal arcs, and by similar arcs in peripheries of different diameters; and an angle is said to be of so many degrees as are contained in the arc of any circle comprehended between the legs of the angle, and having the angular point for its centre. Thus we say "an angle of 90°," or "of 45° 24′." It is also usual to say, "such a star is elevated so many degrees above the horizon," or "declines so many degrees from the equator;" or "such a town is situated in so many degrees of latitude or longitude." A sign of the ecliptic or zodiac contains 30 degrees.

Degree of Latitude is the space or distance on the meridian, through which an observer must move to vary his latitude by one degree, or to increase or diminish the distance of a star from the zenith by one degree; and which, on the supposition of the perfect sphericity of the earth, is the 360th part of the meridian. The length of a degree of a meridian, or other great circle on the surface of the earth, is variously determined by different observers, and the methods made use of are also various; and therefore without entering into the history of all attempts of this kind, we shall present our readers with the following

Table of the different Lengths of a Degree, as measured in various Parts of the Earth, the Time of its Measurement, the Latitude of its middle Point, &c.

Date.	Latitude.			Extent in Eng. miles & decimals.	Measurers.	Countries.
1525	49°	20½′	N.	68.763	M. Fernel	France.
1620	52	4½	N.	66.091	Snellius	Holland.
1635	53	15	N.	69.545	Norwood , . . .	England.
1644				75,066	Riccioli	Italy.
1669	49	22	N.	68.945	Picard	France.
1718				69.119	Cassini	
1737	66	20	N.	69.403	Maupertuis, &c. .	Lapland.
	49	22	N	69.121	Cassini and La Caille	France.
1740	45	00	N.	69.092		
				68.751	Juan and Ulloa	
1741	0	0		68.732	Bouguer . . .	Peru.
				68.713	Condamine . .	
1752	33	18½	S.	69.076	La Caille . . .	Cape of G. Hope.
1755	43	0	N.	68.998	Boscovich . . .	Italy.
1764	44	44	N.	69.061	Beccaria . . .	
1766	47	40	N.	69.142	Liesganig	Germany.
1768	39	12	N.	68.893	Mason and Dixon	U. States.
1802	51	29 54½	N.	69 146	Lieut.-col. Mudge	England.
1803	66	20½	N	69.292	Swanberg, &c. .	Lapland.
	12	32	N.	68.743	Lambton	Mysore.
1808	44	52½	N.	68.769	Biot, Arago, &c.	France.

Ellipticities of the Earth, expressed in Parts of its equatorial Diameter.

Authors.	Ellipticities.	Principles.
Huyghens . . .	$\frac{1}{578}$	Theory of gravity.
Newton	$\frac{1}{230}$	
	$\frac{1}{174}$	
Maupertuis, &c.	$\frac{1}{126}$	Mensuration of arcs.
	$\frac{1}{213}$	
Swanberg . . .	$\frac{1}{323.5}$	
Clairaut	$\frac{1}{177.33}$	Rotatory motion.
	$\frac{1}{337}$	Vibrations of the pendulum.
Treisnsoker . .	$\frac{1}{319}$	Occultations of the fixed stars.
Laplace	$\frac{1}{331}$ $\frac{1}{306}$	Precession, nutation, pendulum, theory of the moon, &c.

Degree of Longitude is the space between two meridians that make an angle of 1° with each other at the poles, the quantity or length of which is variable, according to the latitude. The following table expresses the length of a degree of longitude in different latitudes, supposing the earth to possess a perfect sphericity :—

Deg. Lat.	English miles.	Deg. Lat.	English miles.	Deg. Lat.	English miles.	Deg. Lat.	English miles.	Deg. Lat.	English miles.
0	69.07	19	65.24	38	54.37	57	37.58	76	16.70
1	69.06	20	64.84	39	53.62	58	36.57	77	15.52
2	69.03	21	64.42	40	52.85	59	35.54	78	14.85
3	68.97	22	63.97	41	52.07	60	34 50	79	13.17
4	68.90	23	63.51	42	51.27	61	33.45	80	11.98
5	68.81	24	63.03	43	50.46	62	32.40	81	10.79
6	68.62	25	62.53	44	49.63	63	31.33	82	9.59
7	68.48	26	62.02	45	48.74	64	30.24	83	8.41
8	68.31	27	61.48	46	47.93	65	29.15	84	7.21
9	68.15	28	60.93	47	47.06	66	28.06	85	6.09
10	67.95	29	60.35	48	46.16	67	26.96	86	4.81
11	67.73	30	59.75	49	45.26	68	25.85	87	3.61
12	67.48	31	59.13	50	44.35	69	24.73	88	2 41
13	67.21	32	58.51	51	43.42	70	23.60	89	1.21
14	66.95	33	57.87	52	43.48	71	22.47	90	0.00
15	66.65	34	57.20	53	41.53	72	21.32	—	—
16	66.31	35	56.51	54	40.56	73	20.17	—	—
17	65.98	36	55.81	55	39.58	74	19.02	—	—
18	65.62	37	55.10	56	38.58	75	17.86	—	—

Degrees, Measurement of. After Sir Isaac Newton had taught that the earth, on account of its motion round its axis, must be highest near the equator, and that the diameter of the equator must be longer, by one 230th part, than the diameter from pole to pole, the French wished to investigate the subject farther by actual measurement. Newton gave them warning that the difference between a degree at Bayonne and one at Dunkirk was so trifling that it could not be detected at all with the imperfect instruments then in use; and was, in fact, afraid that they might come to a result directly opposite to what he conceived to be correct, and bring confusion into science. But his warnings were of no avail. The measurement was begun, and the fear of the great philosopher was realized; for the result was, that the axis of the poles was longer than a diameter of the equator, and that the earth was, in form, more like a lemon than an orange. For 40 years, disputes were maintained on this point, without settling the question; and, at last, the Academy of Sciences resolved, on the proposition of Condamine to have a degree measured at the equator (the expedition went to South America in 1735), and one in Lapland (Kittis and Tornea being the extreme stations to which the expedition was sent in 1736). It was found that the northern degree was greater than that under the equator, and that Newton's conjecture was right. But the question still remained, How great is the flattening of our planet? The theory said, one 230th part, if the earth had been in a perfectly liquid state, when it began its rotation. The calculations, however, always gave different results, varying according to the different measurements adopted as the basis of them; for measurements had been made, not only in America and Lapland, but also in France, England, Hungary, and Italy. It was concluded, that the earth was not a regular body, but had great local inequalities. Though this was possible, yet the conclusion was too hasty, because these supposed inequalities might be caused by the insufficiency of the instruments, and by the smallness of the arcs measured.

When the French established their new and admirable system of measures and weights upon the basis of the metre, which was to be the ten millionth part of the distance from the equator to the pole (3$\frac{128}{1000}$ English feet; see Measures), it was necessary to know, with accuracy, the circumference and the flattening of the earth. A measurement took place in France, not of one degree, but of ten degrees, from Dunkirk to Formentera. In Sweden, in 1802, the degree, which, 80 years before, had been measured by Maupertuis, was now measured again, with better instruments, and thus the circumference and flattening of the earth were pretty well ascertained.

After the peace, the measurements of degrees, which were made in England, under General Roy, by Lieutenant-colonel Mudge, were connected with those in France; and thus an arc of 20 degrees, from the Balearic Islands, near the coast of Spain, over France and England, to the Orcades, has been measured, and the flattening of the earth has been determined as accurately as it can be done in Europe. The flattening has been found to be one 304th. In India, Lambton has begun the measurement of a degree.

These measurements of degrees are among those enterprises which do mankind much honour, because they are not undertaken for the sake of immeditate profit, nor of bare utility, but from an ardent desire of knowing the truth, from the same deep thirst for knowledge, which has so often impelled men to explore the icy seas of the poles and the burning deserts of Africa.

The degrees of longitude are largest under the equator, and diminish continually towards the pole. Under the equator, a degree of longitude contains 60 geographical, 69½ statute miles. If the form of the earth is not entirely regular, the degrees of longitude on the same parallel of latitude cannot all be of the same length, and it has been proposed to investigate this by actual measurement. This task is, in the trigonometric part, as easy as the measurment of a degree of latitude; but in the astronomical part, it is 15 times more difficult.

The difference of the longitude of two places is determined by the difference of the hour of the day, at the same point of time in the two; as a place, situate 15 degrees to the east of another, has noon a whole hour earlier. One hour, therefore, corresponds to 15 degrees, or 1042½ statute miles under the equator, or 5,504,400 feet; a minute of time, to 91,740 feet, and

a second of time, to 1529 feet. A mistake of a second of time, therefore, in calculating the longitude of two places, makes a corresponding error in space. To determine time, within two or three seconds, by means of rockets, at a distance of 1042½ miles, is impossible; and, whilst the measurement of an arc, corresponding to this distance, trigonometrically, may be attended with an error to the amount of 200 feet, an astronomical measurement would leave an uncertainty of 2000 feet. The earlier measurements of the French were directed, in the North, by Maupertuis; in the South, by Bouguer.

The latest information respecting this subject is given by Captain Edward Sabine. He made observations with the pendulum, from lat. 13° S. to lat. 80° N. He calculates the flattening of the earth to be $\frac{1}{288.4}$; and if the measurements of Sabine, Kater, and the modern French ones by Biot, are connected, and the mean of the whole taken, the flattening will be found to be $\frac{1}{288.1}$.

Delft-Ware is a kind of pottery covered with an enamel or white glazing, which gives it the appearance and neatness of procelain. Some kinds of this enamelled pottery differ much from others, either in sustaining sudden heat without breaking, or in the beauty and regularity of their forms, of their enamel, and of the painting with which they are ornamented. In general, the fine and beautiful enamelled ware, which approaches the nearest to procelain in external appearances, is that which least resists a brisk fire. Again, those which sustain a sudden heat are coarse, and resemble common pottery. This kind of ware has its name from Delft, in Holland, where it is made in large quantities.

Deltoides, in *anatomy;* one of the large muscles of the arm, so called, because its form is triangular, and therefore resembles that of the capital delta of the Greek alphabet.

Demonstration, in *military* language; a movement towards any place, for the purpose of deceiving the enemy, and concealing the true design.

Denarius. This term was applied by the Romans both to a coin and a weight. As a coin, it was equal to two asses. When the term was employed with reference to weight, it equalled $\frac{1}{96}$ part of the pound. The term is not now employed in France, but was formerly used for 63 grains.

Denominator, in *arithmetic;* a term only used in speaking of fractions, or broken numbers. The denominator of a fraction, is the number, or letter below the line; showing into how many parts the integer is supposed to be divided by the fraction.—Thus in the fraction $\frac{7}{12}$ the number 12 is the denominator, and shows that the integer is here divided into 12 parts.

Density, strictly speaking, denotes vicinity or closeness of particles; but in mechanical science, it is used as a term of comparison, expressing the proportion of the number of equal *moleculæ*, or the quantity of matter in one body, to the number of equal *moleculæ* in the same bulk of another body. Density, therefore, is directly as the quantity of matter, and inversely as the magnitude of the body. Since it may be shown experimentally, that the quantities of matter, or the masses in different bodies, are proportional to their weight; of consequence, the density of any body is directly as its weight, and inversely as its magnitude; or the inverse ratio of the magnitudes of two bodies, having experimentally equal weight (in the same place), constitutes the ratio of their densities. No body is absolutely or perfectly full of matter, so as to have no vacuity or interstices: on the contrary, it is the opinion of Newton, that even the densest bodies, as gold, &c., contain but a small portion of matter, and a great portion of vacuity; or that they contain a great deal more pores or empty space than real substance.

Density of the Earth. The determination of the density of the earth, as compared with that of water, or any other known body, is a subject which has excited considerable interest amongst modern mathematicians; and nothing can, at first sight, seem more beyond the reach of human science, than the due solution of this problem; yet this has been determined, and on such principles, that, if it be not correctly true, it is, probably, an extremely near approximation. The first idea of determining the density of the earth was suggested by M. Bouguer, in consequence of the attraction of Chimborazo, which affected his plumb-line while engaged with Condamine, in measuring a degree of the meridian, near Quito, in Peru. This led to the experiments on the mountain Schehallien, in Scotland, which were carried on under the direction of Dr. Maskelyne, and afterwards submitted to calculation by Dr. Hutton, who determined the density of the earth to be to that of water as 4½ to 1. But in consequence of the specific gravity of the mountain, being assumed rather less than it ought to have been, the above result is less than the true density, as has since been shown by Doctor Hutton and Professor Playfair, the former of whom makes it, in his corrected paper, as 99 to 20, or nearly as 5 to 1. The same problem has been attempted on similar principles, but in a totally different manner, by the late Mr. Cavendish, who found the density of the earth to be to that of water, as 5.48 to 1. Taking a mean of all these, we have the density of the earth to that of water, as 5.24 to 1, and which, as we before observed, is probably an extremely near approximation.

Dentifrice; a preparation for cleaning the teeth, of which there are various kinds. The best dentifrice is the carbon of grape stalk, or the stem of the grape vine converted into charcoal. Dilute sulphuric acid will immediately render them white, but it is highly injurious to them.

Dephlogisticated Air. See Oxygen.

Descant, in *music;* the art of composing in several parts. It is of three kinds, namely, plain, figurative, and double. *Plain descant* is the ground-work of all compositions, consisting altogether in the orderly placing of many concords answering to counter-point. *Figurative descant* is that wherein discords are concerned as well as concords; and this properly may be denominated the ornament, or rhetorical part of music. For in this are introduced all the varieties of points, fuges, syncopes, or bindings, diversity of measures, intermixtures of discordant sounds, or whatever else art and fancy can exhibit, which set forth and adorn the composition; whence it is named florid, or figurative descant. *Double descant* is so called when the parts are so contrived, that the treble may be made the bass, and the bass the treble.

Descension, in *astronomy*, is either right or oblique. Right descension is an arch of the equinoctial, intercepted between the next equinoctial point and the intersection of the meridian, passing through the centre of the object, at its setting, in a right sphere.

Oblique descension, an arch of the equinoctial, intercepted between the next equinoctial point and the horizon, passing through the centre of the object, at its setting, in an oblique sphere.

DESIGN. See DRAWING.

DESSICATION, in *chemistry*, is the act of reducing any substance to perfect dryness, and is an operation the accuracy of which is of very great importance, as the estimation of weights and quantities is materially affected by it.

DETACHMENT, in *military* affairs; a certain number of soldiers drawn out from several regiments or companies equally, to be employed as the general thinks fit, either on an attack, at a seige, or in parties for to scour the country. A detachment of two or three thousand, is a command for a brigadier; eight hundred for a colonel; four or five hundred for a lieutenant-colonel. A captain never marches on a detachment with less than fifty men, a lieutenant, an ensign, and two serjeants. A lieutenant is allowed thirty men and a serjeant; and a serjeant ten or twelve men. Detachments are sometimes made of entire squadrons and battalions.

DETONATION, in *chemistry;* an explosion with noise, made by the inflammation of a combustible body. Decrepitation differs only as producing a fainter noise, or merely a kind of crackling sound peculiar to certain salts. Fulmination is a more quick and lively detonation, such as takes place with certain preparations of gold, silver, mercury, &c.

DETRANCHE, in *heraldry;* a line bendwise, proceeding always from the dexter side, but not from the very angle, diagonally athwart the shield.

DEVICE, in *heraldry;* a name common to all figures, ciphers, characters, rebuses, mottoes, &c., which, by their allusions to the names of persons, of families, &c., denote their qualities, nobility, or the like. Device, in this sense, is of a much older standing than heraldry itself; being that which first gave rise to armorial ensigns. Thus the eagle was the device of the Roman empire. S. P. Q. R. was the device of the Roman people, and still continues to be what is called the escutcheon of the city of Rome. The first devices were mere letters placed on the borders of liveries, housings, and banners, and at length on shields. Thus the C was the device of the French kings of the name of Charles, from Charles V. to Charles IX.

Badges, impresses, and devices were greatly in use in England, from the reign of King Edward I. until that of Queen Elizabeth, when they sunk into disuse. *Device* is now taken in a more limited sense, for an emblem, or a representation of some natural body, with a motto, or sentence, applied in a figurative sense. Thus a young nobleman of great courage and ambition, bore for his device, in a carousal at the court of France, a rocket mounted in the air, with this Italian motto, *Poco duri, purchè m'innalzi* (May I continue but a short time, provided I mount high). A device is, therefore, a painted metaphor. Devices are used on coins, counters, seals, shields, triumphal arches, artificial fire-works, &c. The French have distinguished themselves in the invention of devices, especially since the time of Cardinal Mazarin, who had a great fondness for them. The Italians have reduced the making of devices to an art, and laid down laws and rules for this purpose.

DEW; a phenomenon in nature, which begins to be deposited about sun-set, and is most abundant in valleys and plains near rivers, and other collections of waters, and abounds on those parts of the surface which are clothed with vegetation. It is often suspended when rain is approaching, in windy weather, and before thunder-storms. Its approach, in the extensive valley watered by the Thames, presents the following appearance:—After a clear warm day, there is gradually formed on the horizon a continuous haze, rising sometimes to a considerable height, and often tinged by the setting sun with a fine gradation of red and violet shades. This is the precipitated water, become faintly visible in its descent. Dew is always to be found on the grass by the time that this haze has become conspicuous, and its abundance is proportioned to the density and permanence of the latter. The quantity of dew deposited, differs considerably at different places, and at different seasons in the same place; nor does it fall upon bodies indiscriminately. In explanation of these phenomena, several hypothesis have been suggested, which we have not room to describe; but no theory has yet been established which is quite satisfactory. Upon the whole, however, the obvious and true reason of the formation of dew is, that part of the vapours which are raised in the course of the day by the heat of the sun, and remain floating in the air, are condensed by the cold of the night, and settle upon different bodies; but from various peculiarities which have been observed in the dew, it has been inferred that this is not the cause of its formation. The readiness with which dew falls upon glass, porcelain, and a few other bodies, that are non-conductors of electricity, and the difficulty with which it attaches itself to metallic bodies, which are the best conductors of electricity (see ELECTRICITY), has given reason to suspect that electricity is concerned in the production of this phenomenon; and this opinion is corroborated by the well-ascertained fact, that vapour contains more of electricity than the water from which it originates. In addition to which, it must be recollected, that certain bodies are much better conductors of heat than others, and in general the best conductors of heat are the best conductors of electricity. Hence, it seems more than probable, that the formation of dew, with all its peculiarities, depends upon various causes, which tend to vary the effects according as any one of them happens to preponderate.

In this island the dew is observed (like the drops of a misling rain, upon the leaves of grass and other vegetables, upon wood, glass, porcelain, &c., or upon the earth, which is thereby frequently rendered sensibly moist) more copiously in spring and summer mornings, than at any other times of the year. In autumn, however, and even in winter, it frequently happens that an abundant dew is deposited in the course of the night. In countries situated near the equator, the dews are generally observed in the morning throughout the whole year; and in some places in the east, where rain seldom falls, they are so copious, as in a great measure to supply its deficiency.

DEXTER, in *heraldry*, is applied to the right side, as sinister is to the left. The word is pure Latin, signifying right-handed; whence the word dexterity, for address and ability in the performing of any thing.

DEXTROCHERE, in *heraldry*, is applied to the right arm painted on a shield, sometimes naked, sometimes clothed, or adorned with a bracelet, and

sometimes armed, or holding some moveable, or member used in the arms. The dextrochere is sometimes placed as the crest.

Diacoustics, also called *diaphonics*, is the name of the subject of refracted sound, or that branch of acoustics which considers the passage of sound through different mediums. (See Acoustics).

Diaglyphon, in ancient *sculpture;* the name by which the Greeks designated works in sculpture when sunk in with the chisel. Among the most celebrated of these were the buckler and pedestal of a colossal statue of Minerva at Athens. When it was in relief, the work was called *anaglyphic*.

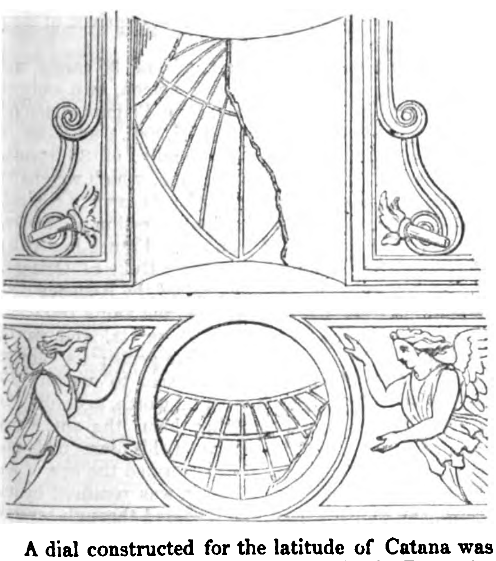
Diagnosis, in *medicine;* the distinction of one disease from others resembling it, by means of a collected view of the symptoms.

Diagnostic symptoms are the leading symptoms, or those which are most characteristic of any particular form or seat of disease.

Diagonal, Diagonal Line; a straight line, joining two angles not adjacent, in a rectilinear figure, having more than three sides. Every rectilinear figure may be divided by diagonals into as many triangles as it has sides, *minus* two.

Diagram; a figure or geometrical delineation, applied to the illustration or solution of geometrical problems, or a description or sketch in general. Anciently, it signified a musical scale. Among the Gnostics, the name *diagram* was given to a figure formed by the superposition of one triangle on another, and inscribed with some mystical name of the Deity, and worn as an amulet.

Dial, Sun. This instrument has been known from the earliest times: the Egyptians, Chaldeans, and Hebrews (*Isaiah* xxxvii. 8) were acquainted with the uses of it. The Greeks derived it from their eastern neighbours, and it was introduced into Rome during the first Punic war. One of the earliest that has been preserved was discovered in the ruins of Herculaneum during the excavations at that place, and it appears to have consisted of a double dial, one portion being formed like a shield, and the other exactly circular.

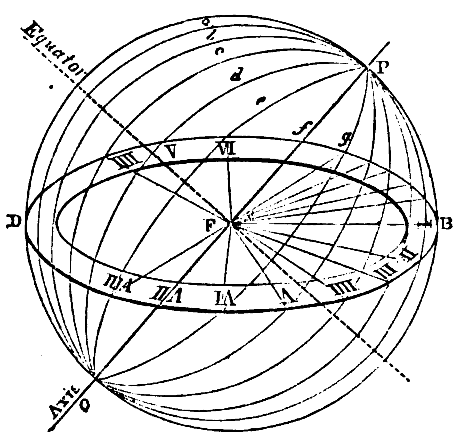


A dial constructed for the latitude of Catana was carried off from that city and placed in the Forum by Valerius Messana; but, as there was a difference of 40° of latitude between the two cities, it could not, of course, indicate the true time at Rome. Before this period, the Romans ascertained the hour by the rude method of observing the lengths of shadows, or, in the absence of the sun, by the clepsydra, which a slave was employed in tending. Sun-dials have lost much of their value in modern times, by the general introduction of instruments which indicate the time at any period of the day or night; but clocks and watches require to be regulated, and the shadows projected by the sun are the most convenient standard for this purpose. Dials are of various kinds; but the horizontal and vertical are most commonly used. In this place, we can give only the general rules of construction applicable to all of them. Suppose 12 planes, making with each other angles of 15°, passing through the axis of the earth and dividing the sphere into 24 equal parts, one of these planes being the meridian of the place of the observer; commence from the meridian, and, moving towards the west, number these planes respectively 1, 2, 3, and so on up to 12, which will be the lower meridian of the place; commencing from this point, number as before, 1, 2, 3, &c., again to 12, which will now fall on the upper meridian. We shall thus have a series of horary circles, in passing from one of which to the next, the sun will occupy one hour. At noon, he will be on the meridian, which is numbered 12; it is then 12 o'clock; an hour before, he was on the last horary circle preceding (to the east), numbered 11, and it was 11 o'clock. Twelve hours from the time of passing the upper meridian, he will pass the lower, also numbered 12, and it will be midnight. Suppose, now, an opaque plane passing through the centre of the earth, and intersected by the 12 planes in as many diverging straight lines, and mark these lines with the numbers belonging to their respective planes. This opaque plane will represent the face of a dial, the straight lines will form the horary lines marked on its surface, and the style will represent the axis of the earth, and will project its shadow successively on each of the hour lines, the number affixed to which will show the hour of the day; that is, at 10 o'clock the shadow will fall on the line numbered 10, &c.

We shall thus have a dial constructed at the centre of the earth; but the radius of the earth, or the distance from its centre to its surface, is so small, in comparison with the distance of the earth from the sun, that it may be considered as nothing: we may, therefore, transport our central dial to any given place, keeping the style and surface always parallel to the positions in which we supposed them at first, and we shall have a dial for that place. This is the theory of dials. It follows, from this explanation, 1. that a sun-dial, calculated for any given place, will also serve for any other place under the same meridian, provided its position in the latter place be parallel to its position in the former place. 2. The style of a dial is parallel to the axis of the earth; the meridian line is the intersection of the plane of the dial and the meridian of the place; the style is in the meridian, and inclines to the rational horizon in the same manner as the terrestrial axis, that is, by an angle equal to the latitude of the place. 3. The hour lines are the intersections of the face of the dial by 12 planes, inclined to each other by an angle of 15°, drawn from the meridian, and passing

through the style. If it is required to mark shorter intervals of time, as half hours, it is only necessary to conceive 24 planes, at an angle of 7½° with each other, and so on for any subdivisions. 4. The hour lines of a dial drawn on a plane are straight lines meeting in the centre of the dial, where the face is penetrated by the style. The forenoon and afternoon hour lines of the same number are given by the intersection of the same horary plane, on the opposite sides of the style. Sometimes the hour is indicated by means of a plate, placed before the dial, having a hole through which the light passes. It is only necessary that this hole should be one of the points of the style; the light will then fall upon that part of the dial where the shadow of the corresponding point of the style would be projected.

To render the theory of the dial still more intelligible, we give a diagram of an imaginary sphere, the degrees being indicated by the letters of the alphabet. P Q forms the imaginary axis, round which the sun is supposed to revolve. The slightest reference to this figure, and the accompanying article, will show how the shadows fall on the hour lines. Sun-dials are, however, in our climate, of comparatively small value. With a clear atmosphere, and an Italian sky, they would be more valuable than a common clock; but here a sun-dial, placed under the most favourable circumstances, would not supply the means for telling the hour for an average of one day in six.



DIAMETER; the straight line drawn through the centre of a circle, and touching the two opposite points of the circumference. It thus divides the circle into two equal parts, and is the greatest chord. The *radius* is half this diameter, and consequently the space comprehended between the centre and circumference of a circle.

DIAMOND; the hardest and most valuable of all the gems. Diamonds are of various colours; but the colourless, which is the sort mostly used in the arts, is when pure, perfectly clear, and pellucid as the purest water. Hence the phrases, the *water* of a diamond, a diamond of the finest *water*, &c. The colourless diamonds are not, however the most common. The rarest colours are blue, pink, and dark brown; but yellow diamonds, when the colour is clear and equal throughout, are very beautiful, and much valued. Pale blue diamonds are also very fine and rare, but deep blue still more rare. The largest diamond hitherto found is said to be in the possession of the Rajah of Mattan, in the island of Borneo, where it was found about eighty years since. It weighs three hundred and sixty-seven carats. It is described as having the shape of an egg, with an indentation near the smaller end. Many years ago, the Governor of of Batavia tried to purchase it, and offered in exchange one hundred and fifty thousand dollars, two large brigs of war, with their guns and ammunition, and other cannon, with powder and shot. But the rajah refused to part with a jewel, to which the Malays attach miraculous powers, and which they imagine to be connected with the fate of his family. This diamond is mentioned in the memoirs of the Batavian Society.

The diamond is the hardest of all known substances. Nothing will scratch it, nor can it be cut but by itself. By cutting, it acquires a brilliancy and play of lustre that much augment its price. The hardness of the diamond was well known to the ancients; its name, both in Greek and Latin implying invincible hardness. The ancients did not confine the word *adamas* to indicate the diamond alone, but applied it to other hard and *adamantine* substances. They were unacquainted with the art of cutting the diamond, satisfying themselves with those which were polished naturally: but knew of the property of its powder or dust for cutting, engraving, and polishing other stones. The art of cutting and polishing the diamond was unknown in Europe till the fifteenth century. Before that period, rough and unpolished ones were set as ornaments, and valued according to the beauty and perfection of their crystallization and transparency. This art is said to have been invented and first practised in 1456, by Louis de Berquen, a native of Bruges. Charles the Bold, Duke of Burgundy, was one of the first princes of modern times who affected a great splendour in diamonds. Among engraved or sculptured diamonds is one with a head, which Gori falsely imagined to be antique, and called it a portrait of Posidonius. It belongs to the Duke of Bedford. Lessing thinks that many of the engraved antique gems, which are called diamonds, are nothing but amethysts, sapphires, and emeralds, deprived of their colour by the operation of fire.

The number of known diamonds of 36 carats and upwards, are not more than nineteen, two only of which are in England, viz. the Piggott diamond weighing 45 carats, and worth 16,200*l.*; and one in the possession of the Hornsby family, of 36 carats, worth 8000*l.* Holland has but one, which weighs 53 carats, and is valued at 10,368*l.*; its form is conical, and it was for some time in the possession of Messrs. Rundell and Bridge, of London. France has two; the largest was bought by a former Duke of Orleans, during his regency, and thus called the Regency diamond; its weight is 136¼ carats, and value 149,058*l.* Germany has one weighing 139½ carats, and worth 155,682*l.* Russia is rich in these gems; its largest is that of the Sceptre, which is said to weigh 779 carats. If this be true, it must be worth, according to the general mode of estimating them, the enormous sum of 4,854,728*l.* The history of this diamond is rather curious; for a long time it formed the eye of an Indian idol, from which post it was removed by an European soldier; from him it passed through several hands, and was finally sold to the Empress Catherine, for 90,000*l.*, a handsome annuity, and a patent of

nobility. Russia has several others, one of which is estimated at 369,800*l*. The Great Mogul has one of a rose colour, and valued at 622,728*l*. The two principal ones belonging to Persia are called in the hyperbolical language of the east, "The Mountain of Splendour," &c., and "The Sea of Glory;" one is worth 145,800*l*. and the other 34,848*l*. The Portuguese royal family have two, one of which is still uncut; and, if we may credit the Portuguese accounts, is the largest ever found: it is said to weigh 1680 carats; and, supposing it to lose half its weight in cutting, it would be worth 5,644,800*l*., upwards of a million more than the Sceptre diamond of Russia. There is a small part broken off, which was done by the man who found it; who, ignorant what stone it was, struck it with a hammer upon an anvil. It was found at the Brazils. It may be proper to state, that some persons doubt the existence of this stone. According to the model exhibited, it is somewhat like the shape and size of an ostrich's egg. The other diamond, in the possession of the house of Braganza, is worth 3,698,000*l*.

An application of the diamond of great importance in the art of engraving, has been made within a few years by the late Wilson Lowry, for the purpose of drawing or ruling lines, which are afterwards to be deepened by aqua-fortis. Formerly steel points called *etching needles*, were used for that purpose; but they soon became blunt by the friction against the copper, so that it has always been found impracticable to make what are called *flat* or *even* tints with them; such as the azure of skies, large architectural subjects, and the sea in maps; but the diamond, being turned to a conical point, or otherwise cut to a proper form, is not worn away by the friction of the copper, and, consequently, the lines drawn by it are all of equal thickness. The diamond etching points of Mr. Lowry are turned in a lathe, by holding a thin splinter of diamond against them as a chisel.

Diamond, in *manufactures;* an instrument of considerable use in the glass manufactory, for squaring the large plates, or pieces; and among glaziers for cutting their glass. These diamonds are differently fitted up. That used for looking-glasses, and other large pieces, is set in an iron ferril two inches long, and a quarter of an inch in diameter. The rest of the cavity of the ferril is filled with melted lead, which keeps the diamond firm in its place. The glaziers have a handle of box or ebony, fitted into the ferril to hold it by.

Diapason. By the term *diapason*, the ancient Greeks expressed the interval of the octave. And certain musical instrument-makers have a kind of rule or scale, called the *diapason*, by which they determine the measures of the pipes, or other parts of their instruments. There is a diapason for trumpets and serpents. Bell-founders have also a diapason, for the regulation of the size, thickness, weight, &c., of their bells. *Diapason* is likewise the appellation given to certain stops in an organ. (See Stop.)

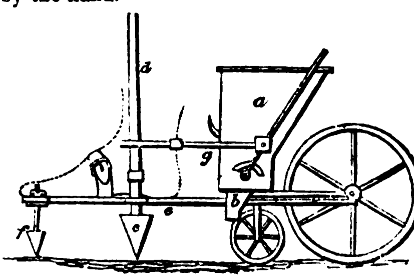
Diaper; so called from *Ypres* (*d'Ypres*); linen cloth woven in flowers and other figures; the finest species of figured linen after damask. Hence, as a verb, it signifies to diversify or variegate with flowers, or to imitate diaper.

Diaphragm, in *anatomy;* a large, robust, muscular membrane or skin, placed transversely in the trunk, and dividing the chest from the belly. In its natural situation, the diaphragm is convex on the upper side towards the breast, and concave on its lower side towards the belly; therefore, when its fibres swell and contract, it must become plain on each side: and consequently the cavity of the breast is enlarged, to give liberty to the lungs to receive air in inspiration; and the stomach and intestines are pressed for the distribution of their contents; hence the use of this muscle is very considerable. It is the principal agent in respiration, particularly in inspiration; for, when it is in action, the cavity of the chest is enlarged, particularly at the sides, where the lungs are chiefly situated; and, as the lungs must always be contiguous to the inside of the chest and upper side of the diaphragm, the air rushes into them, in order to fill up the increased space. In expiration, it is relaxed, and pushed up by the pressure of the abdominal muscles upon the viscera of the abdomen; and, at the same time that they press it upwards, they pull down the ribs, by which the cavity of the chest is diminished, and the air suddenly pushed out of the lungs.

Diatonic; a term in *music*, applied by the Greeks to that one of their three genera, which consisted, like the modern system of intervals, of major tones and semitones. The diatonic genus has long since been considered as more natural than either the chromatic or enharmonic. Aristoxenus asserts it to have been the first, and informs us that the other two were formed from the division of its intervals.

Diatonum Intensum, or Sharp Diatonic; the name given by musical theorists to those famous proportions of the intervals proposed by Ptolemy, in his system of that name; a system which, long after the time of this ancient speculative musician, was received in our counterpoint, and is pronounced by Doctor Wallis, Doctor Smith, and the most learned writers on harmonics, to be the best division of the scale.

Dibble; an agricultural implement employed in making holes in the ground for setting grains, plants, and other sorts of crops in, which are planted in rows. Their form, and the materials of which they are made, differs according to the nature of the crop which is to be put in or planted out by them; but for grain they are mostly shod with iron. In some cases they have likewise a sort of step for setting the foot upon, in using them. When employed, they are thrust into the ground to a depth suitable to the crop which is to be put in by them, and holes thus formed, into which the seeds, sets, or plants, are put by the hand.



We give the above engraving of a dibble acting by the foot as already described; *a* represents the depository for the seed, &c.; the discharge valve is shown at *b*, the opening and shutting of the hopper being by a double lever, *g*, resting against the heel above, *e*: the dibble-iron and guide is shown at *c f*.

Dice; cubical pieces of bone or ivory, marked with dots on each of their six faces, from one to six, according to the number of faces. Numerous passages in the ancient writers, and very many representations in marble or paintings, show how frequent dice-playing was among them. Different from the *tesseræ*, which were precisely like our dice, were the *tali* (which means, originally, the pastern bone of a beast). These were almost of a cubic form, and had numbers only on four sides, lengthwise. Three *tesseræ* and four *tali* were often used together; and the game with dice was properly called *alea*, though *alea* afterwards came to signify any game at hazard, and *aleator*, a gambler. Dice-playing, and all games of chance, were prohibited by several laws of the Romans, except in December, yet the laws were not strictly observed.

Diet. The dietetic part of medicine is an important branch, and seems to require a much greater share of attention than it commonly meets with. A great variety of diseases might be removed by the observance of a proper diet and regimen, without the assistance of medicine, were it not for the impatience of the sufferers. It may, however, on all occasions, come in as a proper assistant to the cure. That food is, in general, thought the best and most conducive to long life, which is most simple, pure, and free from irritating qualities, and is capable of being most easily converted into the substance of the body after it has been duly prepared by the art of cookery; but the nature, composition, virtues, and uses of particular aliments can never be learnt to satisfaction, without the assistance of practical chemistry. (See Food.)

Diet Drink; an alterative decoction employed daily in considerable quantities, at least from a pint to a quart. The decoction of sarsaparilla and mezereon, the Lisbon diet drink, is the most common and most useful.

Digester; an instrument invented by Mr. Papin. It consists of a strong vessel of copper or iron, with a cover adapted to screw on, with pieces of felt or pasteboard interposed. A valve with a small aperture is made in the cover, the stopper of which valve may be more or less loaded, either by actual weights, or by pressure from an apparatus on the principle of the steelyard. The purpose of this instrument is to prevent the loss of heat by evaporation. Water may be thus heated to 400° Fahr.; at which temperature its solvent power is greatly increased.

Digestion is that process in the animal body, by which the aliments are dissolved, and the nutritive parts separated, for the revivification of the frame. For the support and continuance of life in all classes of animals, we find a series of organs constructed by the all-wise Creator, for the purpose of preparing the food, so that its nutritious particles only shall be received into the circulatory system, and form a new portion of the vital fluid, in lieu of that which is constantly expended in the various secretions of the body, thus repairing the waste that is continually going on.

The organs that are employed for this purpose, are the stomach and intestines, liver, pancreas, or sweetbread, which may be severally described:—

The *stomach* is the well-known receptacle of the food, a large membranous bag, and is said to resemble in shape the Scotch bagpipes: it is situated immediately beneath the short ribs on the left side, and when distended with food or air, reaches nearly to the right. Like the intestines, it is composed of three coats; the external is denominated the serous, being formed of a reflection of the peritoneal lining of the abdominal cavity; the middle is formed of a tissue of muscular fibres, which perform an important office during digestion; the internal, from its resemblance to velvet, is named the villous; this is extremely vascular, and when minutely injected, either by blood or by artificial means, it resembles a mass of vermilion. To this coat the glands that secrete the gastric juice are connected, which, in some of the carnivorous birds, are extremely large, and whose ducts perforate this villous coat. Some anatomists assert the existence of a nervous coat to the stomach as well as to the intestines, but this has been denied; at the same time it must be admitted by every attentive anatomist, that it is abundantly supplied with nerves, which will account in many instances for those derangements of the constitution arising from indigestion. The left extremity is the greatest, and is denominated the larger curvature; the right is the lesser, and is attached to the first portion of the small intestines, by an intervening circular valve, denominated the pylorus. The stomach is supplied with blood by the first branch of the cœliac artery. The office of the stomach is to secrete a fluid for the purposes of digestion, and is denominated the gastric juice.

The small intestines are divided into three parts, viz. the *duodenum*, *jejunum*, and *ileum*; but this distinction may be considered arbitrary, inasmuch as there is no material difference in their structure. It consists of a long membranous tube, about an inch or an inch and a half in diameter, and is considered to be four times the length of the subject; notwithstanding this great length, it is collected by means of numerous windings and convolutions, into a comparatively small compass. These convolutions of the small intestine occupy the chief part of the umbilical region of the abdomen. They are connected in their situation by means of a broad folded membrane, called the *mesentery*. This production of the peritoneum is about six inches broad from its commencement, but it gradually expands, something after the manner of a fan, so that it becomes broad enough, ultimately, to cover the whole length of the small intestine. It keeps the different convolutions of the small intestines in their relative position, allowing at the same period, very considerable freedom of motion without the least danger of entanglement. If we trace the course of the small intestine, we follow the *duodenum* from the lesser extremity of the stomach in the right *hypochondrium*, which makes three turns close upon the spine, and then comes out just over the left kidney. The general direction of the canal from this point, independently of its various turnings and windings, is towards the right groin, where the *ileum* terminates by entering the *cæcum*.

The coats of the smaller intestines are similar in structure to the stomach, but as the villous coat in that organ is formed into a series of folds, so the analogy is continued to this portion of the alimentary canal, inasmuch as there are a great number of loose, transverse, and floating processes, named the *valvulæ conniventes*, by which means the extent of surface of the villous coat is considerably augmented. However, this peculiarity of structure is not found in the *fœtus*, and young subject, and is deficient in many

animals. Numerous glandular bodies are found in various parts of the canal, collected into small parcels, and hence they are called the *glandulæ aggregatæ*.

The large intestine is a canal of about two or three inches in diameter, and seven feet in length. It is divided into the cæcum, colon, and rectum. The cæcum is a kind of pouch situated in the right groin, and receiving the termination of the ileum. There is a valve placed at this part, by which means the contents of the intestine are allowed to pass from the ileum into the cæcum, but are prevented from returning. A small process, about the size of an earthworm is attached to the cæcum. It is consequently named the *appendix vermiformis cæci*, but its use is as yet unknown.

The course of the large intestine is as follows:—From the right groin it ascends on the same side of the abdomen over the kidney, under the name of colon: it turns completely over the abdomen at its upper part, immediately below the inferior margin of the stomach, and descends on the left side to the left groin: here it makes a large turn over the brim of the pelvis, and enters that cavity, where it takes the name of rectum, terminating in the anus.

The large intestines have the same number of coats of the small portions of this canal: but they have *no* valvulæ conniventes. The longitudinal muscular fibres are collected into three bands, which being shorter than the rest of the intestine, occasion the other coats to be gathered up in folds between them.

The next object of importance, as connected with digestion, is the liver, which is situated at the superior part of the abdomen; the use of this organ is to secrete the bile, a fluid intimately connected with chylification, a healthy supply of which is absolutely necessary for the nourishment of the animal. The bile is secreted from venous blood, collected from all the veins of the intestines and of the glands in the abdomen; and entering the liver by a large trunk, which is denominated the *vena portarum*, and is minutely distributed throughout its substance, in numerous and minute ramifications, and after an endless series of undefinable communications with each other, terminating in ducts so exceedingly minute as to exclude the red globules of the blood. This, in fact, is the commencement of the formation of the bile, which is carried on, the ducts gradually enlarging by an union of branches, till it is conveyed into one trunk, called the hepatic duct; this joining the cystic duct, forms the common bile duct, through which the bile is carried into the duodenum to assist in the process of chylification. As the circulation of this immense quantity of blood through the liver is constant and uniform, so is also the secretion of bile. But as this fluid is not always wanted in the duodenum, the great Author of Nature has provided it with a receptacle, called the gall bladder; to this organ the superabundant bile is conveyed by the cystic duct, where it remains until called for by the purposes of digestion. Human bile, according to M. Thenard, is composed, in 1,100 parts, of

Water	1000
A yellow insoluble matter, from . .	2 to 10
Albumen	42
Resin	41.
Soda	5.6
Phosphates of soda and lime, Sulphate and muriate of soda, and oxide of iron	45.

The *pancreas*, or sweet-bread, is a conglomerate gland, composed of minute portions united together by a cellular substance. It is connected by one end to the commencement of the duodenum, extending across the spine, behind the lesser arch of the stomach towards the spleen. Its length is about six inches, its breadth one and a half, and its thickness half an inch. It secretes a fluid necessary for chylification, called the pancreatic juice, but it is very small in quantity; and Dr. Majendie, of Paris, who has been making experiments on the pancreatic juice, observes, "*the quantity passed into the duodenum was scarcely a drop an hour*;" and, he says, "*I have waited longer than that for it*;" yet, small as it is in quantity, it performs a very important part in the elaboration of the chyle, as appears evident from the fact, that in diseases of the viscus, the body is attended with emaciation.

Having thus described the organs and fluids necessary for the process of digestion, we may now proceed to describe that process. The food is taken into the mouth, and broken down, or chewed by the teeth; it is then mixed with the saliva; it is next propelled by the muscles of the mouth into the pharynx, the constrictor muscles of which, propel it into the œsophagus or gullet; the contraction of its muscular parietes force it into the stomach, where it becomes mixed with the gastric juice; in a short time this juice acts on the food, and an homogenous mass is formed, called *chyme*, quite different from its original state. The pylrous dilates, the muscular coat of the stomach contracts, and the chyme is forced into the duodenum, where it mixes with the bile and pancreatic juice; the process of chylification then takes place, when the nutritious portions of the food are extracted by a series of vessels in the small intestines, called the lacteals, and from them it passes into a vessel lying on the spine, denominated the thoracic duct, which terminates in a large vein under the left collar bone, called the subclavian, where it enters the circulation of the blood. The useless and excrementitious parts pass through the large intestines, and are finally ejected.

Digestion, with chemists and apothecaries; the maceration of any substance which is to be softened or dissolved, commonly pulverized, in a solvent liquid. It is enclosed in a tight vessel, and exposed to a gentle heat for a longer or shorter time. By this process essences, elixirs, and tinctures are made.

DIGIT, in *arithmetic*, signifies any one of the ten numerals, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0. The word comes from *digitus*, a finger; thus indicating the humble means originally employed in computations. Digit is also a measure equal to three-fourths of an inch.

Digit, in *astronomy*, is the measure by which we estimate the quantity of an eclipse. The diameter of the sun or moon's disc is conceived to be divided into 12 equal parts, called *digits;* and, according to the number of those parts or digits which are obscured, so many digits are said to be eclipsed. When the luminary is wholly covered, the digits eclipsed are precisely 12; and when it is more than covered, as is frequently the case in lunar eclipses, then more than 12 digits are said to be eclipsed.

DIGITALINE is the active principle of the *digitalis purpurea*, or foxglove, and is a very powerful poison, possessing all the properties of *digitalis*, in a very concentrated state. To prepare it, the leaves are di-

gested in ether, the solution filtered and evaporated, and the residue dissolved in water: this solution is heated with oxide of lead, filtered and evaporated, and the residuum digested in ether, which affords digitaline, on evaporation. It is a brown-coloured substance, deliquescent, and extremely bitter. It restores the colour of reddened litmus, and combines with acids.

Digitalis; a genus of plants, including, among other species, the purple foxglove, a vegetable which, as we have already stated, possesses important medicinal properties. The plant, when fresh, possesses a bitter, nauseous taste, and is violently emetic and cathartic. When prepared, and administered medicinally, it has the remarkable property of diminishing the strength and frequency of the pulse, and is, at the same time, diuretic.

Dike, or Dyke; a ditch or drain, and also a work of stone, timber, or fascines, raised to oppose the passage of the waters of the sea, a lake, river, or the like. In no country has the art of building dikes, and their subsequent management, been carried to so much perfection as in Holland, and the north-west of Germany, where the construction and superintendance of them, the draining of land and guarding against inundations, and the distribution of taxes for the maintenance of the dikes, form an important branch of government.

Dioptrics. See Optics.

Diorama. This term is now generally employed to describe pictorial representations. One of the principal of these is exhibited in the Regent's Park, and consists of two large transparent pictures, which are seen from a revolving room, so that the visitor can be brought alternately before either of the pictures. The effect of a thunder-storm, and, indeed, of variable lights generally, are in these pictures produced by differently coloured mediums through which the light is admitted, and these are made to move by machinery.

Diploe, in *anatomy*, is the reticular texture connecting together the two tables of the skull. (See Cranium.)

Dipping, among miners, signifies the interruption of a vein of ore—an accident that often gives them a great deal of trouble before they can discover the ore again.

Dipping Needle, or Inclinatory Needle; a magnetical needle, so hung, that instead of playing horizontally, and pointing north and south, one end dips or inclines to the horizon, and the other points to a certain height above it. The inventor of this instrument was Robert Norman, a compass-maker, of Wapping, about the year 1576.

Some persons have endeavoured to find the latitude and longitude of places by means of the dipping needle; but nothing of importance has followed from their attempts. The following general rule, however, may be adopted, in order to find the longitude or latitude by the dipping needle. If the lines of equal dip, below the horizon, be drawn on maps or sea-charts, from good observations, it will be easy from the longitude known, to find the latitude, and from the latitude known, to find the longitude. Suppose, for example, a person travelling or sailing along the meridian of London, and found the angle of dip, with a needle of one foot, to be 75°, the chart will show, that this meridian and the line of dip meet in the latitude of 53° 11′, which therefore is the latitude sought. Or suppose a person travelling along the parallel of London, *i. e.* in 51° 32′ N. lat., and he find the angle of dip to be 74°, this parallel, and the line of this dip, will meet in the map in 1° 46′ of E. lon. from London, which is therefore the longitude sought. The dip is not always the same.

Discord. A *discord* is a dissonant or inharmonious combination of sounds, so called in opposition to the *concord*, the effects of which the discord is calculated to relieve by contrast. Among various other discords, are those formed by the union of the fifth with the sixth, the fourth with the fifth, the seventh with the eighth, and the third with the ninth and seventh, all which require to be introduced by certain preparatives, and to be succeeded by concords to which they have some relation.

Discus, Disc, or Disk; among the Greeks and Romans, a quoit of stone or metal, convex on both its sides, perforated in the middle, and fastened to the hand by strings. Throwing the *discus* was one of the gymnastic exercises; and in the Olympic and other games, it was considered a great honour to conquer in the contest. Perseus is said to have invented this instrument, and Apollo killed his favourite, Hyacinth, with it. In some places, the plate which contains the host during the act of consecration, is called *disk*.

Diseases, Hereditary. The influence of the parents on the organization of the child is so great, that even the individual peculiarities which distinguish one man from another are, in part at least, transmitted to his children; hence the similarity, in person and looks, of the child to its parents. The internal organs, too, as well as the external form, have the same resemblance; so that the peculiar constitution, the greater or less activity and developement of these organs, are found to pass from parent to child. Now as it is the particular state of the several organs and functions, in which a very great part of diseases have their foundation, it follows that these diseases may be inherited; and, in fact, it has been observed, that the son is not unfrequently attacked by a disease at the same period of life in which his father was. These diseases are called *hereditary;* but it is only the predisposition to them that is, properly speaking, inherited. Hence the actual developement of hereditary diseases requires certain co-operating circumstances.

Constitutional diseases are very often not hereditary, but depend on circumstances which affect the fœtus, during pregnancy. The father has no influence on the child, beyond the act of generation; the mother operates upon it during pregnancy, and it is possible that hereby occasion may be given to hereditary diseases. Among the diseases which are most frequently hereditary, are scrofula, bleeding (especially at the lungs) and hemorrhoids, consumption, gout, the gravel and stone, scirrhus and cancer, disorders of the mind and spirits, hysterical and hypochondriac affections, apoplexy, epilepsy, and organic diseases of particular parts, especially of the heart. They have this peculiarity, that they are produced, and appear as constitutional diseases, more from the action of internal than of external, of predisposing than of occasional causes.

Such diseases are more difficult to reach and to cure than those which originate in accidental, external causes. Hence it is especially necessary to prevent in season their growth and developement. The means of doing this are the following: 1. Whoever has a hereditary predisposition to any disease, should

not marry one who has the same constitution. For this reason, marriages between near relations are not advisable, as tending to perpetuate such hereditary diseases. This too appears to be the reason why attachments are generally formed between persons of opposite constitution and different temperament. 2. We ought to order all the circumstances, in which the child grows up, in such a way, that the inherited predisposition may not only not be favoured, but counteracted. 3. The accidental occasions which favour the growth of the disease should be avoided, especially at the time of life in which the father was attacked by it. The medical treatment of hereditary diseases is not essentially different from that which is requisite in the same diseases, arising under different circumstances.

Disk, in *astronomy*, means the face of the sun and moon, as they appear to observers on the earth.

Dismounting, in the *military* art, is rendering the enemy's cannon unfit for further service, by breaking their carriages and axle-trees; also shattering the parapet of a retrenchment or of a wall, by balls, so that it cannot be defended, particularly so that cannons cannot be worked behind it. Dismounting batteries are such as are intended to throw down the parapets of fortifications, and disable the enemy's cannons. They are placed generally in the second, often in the third parallel. If they are on the glacis, in the salient angles of the bastions, and fire against the flanks of the adjacent bulwark, they are called *counter-batteries*. They are erected exactly opposite the front to be battered, and consist of from four to eight cannons, mostly 12-pounders. These cannons are generally aimed, at the same time, at the same embrasure, whilst the others occupy the other cannon of the enemy: when one of the enemy's cannon is silenced, the fire is directed to another, and so on. Some mortars and howitzers, which may be placed either within the dismounting battery or by themselves, support its fire, by bombarding the attacked embrasures: the fire of both must be slow, and well aimed. The distance of the dismounting battery from the work attacked, is usually from 3 to 400 paces, according to the distance of the second parallel. It has been proposed, in modern times, to shoot grenades, instead of balls, from the cannons, into the works which are to be dismounted, to produce an effect, by their bursting, similar to that of mines.

Dispensatory; a book in which all the medicines are registered, that are to be kept in an apothecary's shop, and the apothecaries directed how to compose them. Almost every country in Europe, and many large cities have their own dispensatories, which the apothecaries or chemists are bound to follow.

Displayed, in *heraldry*, is understood of the position of an eagle, or other bird, when it is erect, with its wings expanded, or spread forth.

Dissonance; that effect which results from the union of two sounds not in accord with each other. The ancients considered thirds and sixths as *dissonances*; and, in fact, every chord, except the perfect concord, is a dissonant chord. The old theories include an infinity of dissonances, but the present received system reduces them to a comparatively small number. One rule, admitted both by the ancients and the moderns, is, that of two notes, dissonant between themselves, the dissonance appertains to that one of the two which is most remote from the concord.

Distillation is an art founded upon the different tendencies which bodies have to pass into vapour, and to be condensed again by cold, and is performed in order to separate them from each other, when combined, or when they become products of chemical action. Its use is very important in obtaining spirits, essences, volatile oils, &c. The most common method of conducting this process consists in placing the liquid to be distilled in a vessel called a *still*, made of copper, having a moveable head, with a swan-like neck, which is so formed as to fit a coiled tube, packed away in a tub of water constantly kept cold, and which is termed a *refrigeratory*. The fire is applied either immediately to the still, or mediately, by means of a water or sand-bath. The liquid to be obtained rises, in vapour, into the head of the still, and, passing down the curved tube, or worm, becomes condensed, and makes its exit in a liquid state. The still should be constructed with a diameter considerably greater than its height, in order to expose a larger surface to the fire; and the tube should not be so narrow as to impede the passage of the vapour into the worm. (See Alcohol and Rectification.)

An improvement made by Mr. Tennant in this apparatus, consists in introducing the spiral tube into the body of a second still, so that the heat from the condensation of the steam passing through the tube, is applied to the distillation of liquor in the second. The pressure of the atmosphere is removed from the latter, by connecting it with an air-tight receiver, kept cool. The air in this receiver is allowed to escape at the commencement; its place is occupied by the steam from the liquor, which being condensed, a vacuum is kept up, and the distillation proceeds, without any farther heat being applied to the second still. This form of distilling apparatus is called the *double still*, and has been much improved by Mr. Sharp.

The process introduced by Mr. Barry, for preparing vegetable extracts and inspissated juices, by evaporation *in vacuo*, is of a somewhat similar nature. The apparatus consists of a hemispherical still, made of cast iron, and polished within. It is closed by an air-tight, flat cover, through which rises a wide tube, which is then bent downwards, and terminates in a large copper globe, of a capacity three or four times greater than that of the still.

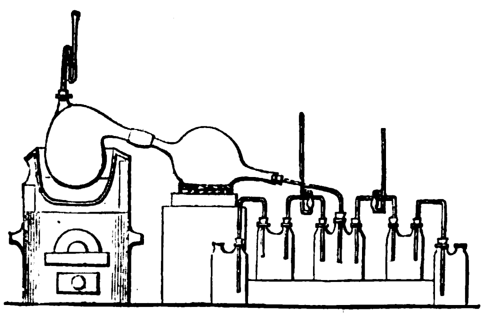
In this tube there is a stop-cock, between the still and the globe. When evaporation is to be performed, the vegetable juice or infusion is poured into the polished iron still, through an opening, which is then closed, made air-tight, and covered with water. In order to produce a vacuum, the connection between the still and copper receiver is interrupted, by shutting the stop-cock, and steam from a boiler is introduced by a pipe into the latter, till the whole of the air is expelled from it. This takes usually about five minutes, and is known by the steam issuing from the globe uncondensed. The copper sphere is then closed, and the communication restored between it and the still, by opening the stop-cock, when the greater part of the air in the latter rushes into the former. The stop-cock is again closed, and the globe again filled with steam as before. By the condensation of this steam, a vacuum is again produced, which, on opening the stop-cock, extracts the greater portion of the

air remaining in the still: in short, by repeating these exhaustions five or six times, an almost perfect vacuum is obtained, both in the still and receiver. Heat is then applied to the water-bath, in which the still is placed, until the juice within begins to boil, which is ascertained by inspection through a piece of thick glass, fixed firmly in the upper part of the apparatus.

As in a vacuum, fluids boil many degrees below their usual boiling temperature, water passes into ebullition, in such circumstances, at 90° Fahr., or a little above it; and it is never found necessary to heat the juice above a temparature of 100°. The evaporation is continued till the fluid is inspissated to the proper extent, which is judged by its appearance through the glass. Extracts prepared in this way, are found to be greatly preferable to those obtained by evaporation at a high temperature; they are considerably stronger, as the active principles in the juices are not decomposed by re-action between their elements, favoured by heat; and they are free from all burnt flavour, or empyreuma.

There are many operations, however, in which liquids are employed, that would corrode metallic vessels: in such cases, vessels are employed, constructed either of glass, platinum, or stone ware. In this case we generally employ a modification of Woulfe's bottles. This apparatus is one of the greatest improvements that could have been introduced in our laboratories. It not only affords us the means of collecting all the products of a distillation, but also enables us to obtain them separately; and it removes all fear of any risk or accident.

In certain cases, the product designed to be obtained by distillation, is an elastic fluid, not condensible by itself, but capable of being condensed by being transmitted through water, with which it is retained in combination. The distillatory apparatus invented by Woulfe, consists of a series of bottles, as shown in the accompanying diagram, connected with each



other by bent tubes, and connected with a retort, generally by the medium of a receiver and adopter. The receiver is designed to collect any condensible part of the product. In the three bottles, water is placed to nearly one half their height, and the tube passing from one into the other, beyond the second bottle, dips into the water of the bottle into which it is inserted. The gaseous product is thus transmitted through the water, by which, as well as by the pressure which is necessarily exerted by the short column of water in each tube, its absorbtion is promoted; and if any portion is incapable of being absorbed by the water, it passes off by the bent tube at the end, and may be collected in an inverted jar, in a trough of water. Each of the bottles, except the first receiver, has a straight tube, which rises to the height of 8, 10, or 12 inches above its insertion into the bottle, and passes so far within it as to dip in the water nearly half an inch. This tube is termed the tube of safety, and the use of it is to guard against that reflux of fluid which might happen from a partial vacuum arising from condensation in any of the bottles. At the commencement of the distillation, the joinings of the tubes with the bottles being well secured, the whole is air-tight; and, by the gas produced, the atmospheric air contained in the upper part of the bottles is in a great measure expelled through the tubes. If, therefore, in any stage of the distillation, the production of gas should diminish, the quantity contained in the bottles being absorbed by the liquor, a partial vacuum is formed; and, at the end of the process, when the retort cools, which always happens: the consequence of this must be, that the water being more pressed on by the atmospheric air without, than by the gas within, must pass backwards from one bottle to another by rising through the tubes, and thus the whole will be mingled together, which would often defeat the object of the distillation. This however, is effectually prevented by the tubes of safety, as when any such partial vacuum happens, the atmospheric air is forced through the small quantity of fluid in which they are immersed, and rising into the bottles, preserves the equilibrium.

Various improvements have been made in this apparatus. One defect in it is, that we cannot have the advantage of the immersion of the tube which comes from the first receiver, into the liquid in the second; for, as the receiver, as it sometimes is, is designed to collect the condensible product, and ought therefore, to be without water, it can have no tube of safety; and hence, if the tube issuing from it dip into the liquid in the second, whenever any condensation happens, from the gas ceasing to be produced, the liquor will pass backwards into it. As the liquid, however, in the first bottle is in the best situation for being impregnated with the gas, and therefore, for forming the most concentrated product, it is of some importance to aid this as much as possible, and obtain the advantage of the gas being forced to pass through it, by the tube passing into it being immersed. The contrivance that has been used for this purpose, is the tube of safety of Welter, or bent tube with an additional curvature, and a spherical ball intermediate between the globular receiver and the common three-necked bottle, and connecting them. In this is put a small quantity of water, so as to rise, when the pressure without and within is equal, about half way into the ball. If the elasticity is increased in the internal part of the apparatus, during the distillation, by the production of gas, the water is pressed upwards to the funnel at the top; if there is a condensation, it is forced by the atmospheric pressure, into the ball, but whenever it has passed the curvature beneath the ball, it is obvious that a portion of air must rise through it, and will pass into the globe or bottle, to the tube of which this bent tube is adapted.

Divergent, in *geometry*, are lines whose distance from each other are continually increasing.

Diverging Series, in analysis, are those series, the terms of which increase more and more, the farther they are continued.

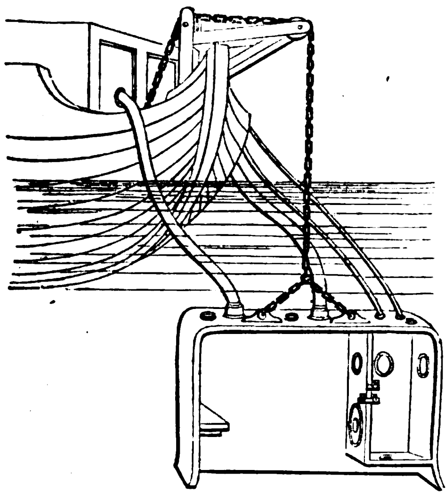
Diversion, in *military* affairs, is an attack on an

enemy, in a place where he is weak and unprovided, in order to draw off his forces from another place, where they have made, or intend to make, an irruption. Thus the Romans had no other way in their power of driving Hannibal out of Italy, but by making a diversion by attacking Carthage.

DIVIDED, in *arithmetic*, is that number to be divided.

DIVING-BELL. To illustrate the principle of this machine, let the experimentor take a glass tumbler, plunge it into water with the mouth perpendicularly downwards; he will find that very little water will rise into the tumbler, which will be evident if he lay a piece of cork upon the surface of the water, and put the tumbler over it; for it will be seen, that, though the cork should be carried far below the surface of the water, yet its upper side is not wetted, the air which was in the tumbler having prevented the entrance of the water; but, as air is compressible, it could not entirely exclude the water, which, by its pressure, condensed the air a little.

The general arrangement of the bell, as it is allowed to descend by its gravity in the water, will be understood by referring to the diagram beneath.



The first diving-bell we read of in Europe was tried at Cadiz, by two Greeks, in the presence of Charles V. and 10,000 spectators. It resembled a large kettle inverted. The first of any note was made by Dr. Halley. It is most commonly made in the form of a truncated cone, the smallest end being closed, and the larger one open. It is so suspended that it may sink full of air, with its open base downwards, and as near as may be parallel to the horizon, so as to close with the surface of the water. Mr. Smeaton's diving-bell, made in 1788, was a square chest of cast iron, 4½ feet in height, 4½ feet in length, and 3 feet wide, and afforded room for two men to work in it. It was supplied with fresh air by a forcing pump. This was used with great success at Ramsgate.

Other contrivances have been used for diving-bells. Within the last 30 years, the diving-bell has been much employed to assist in laying the foundations of buildings under water. A diving-bell, on an improved principle, was constructed in 1812, by the late Mr. Rennie, and employed in Ramsgate harbour, where it answered so well, that the masonry was laid with the utmost precision. From this period must be dated a new era in the construction of masonry under water, the use of coffer-dams being, in a considerable degree, superseded. The diving-bell was thenceforward employed by Mr. Rennie in the construction of all the great harbours which he projected. Round bells of cast-iron and copper have been occasionally made for the pearl and coral fisheries of South America, and have been supplied by the Messrs. Rennie for most of the royal dock-yards in England, and several of those in the colonies, for the pearl fishery at Ceylon, for the repair of the works at Cronstadt, and for many places in Great Britain and Ireland.

We shall now present our readers with a short description of a diving-bell, which was used at Sheerness in building a new sea-wall round the dock-yard at that place, and which is thought to be one of the best pieces of under-water masonry that has yet been constructed. This description is translated from the valuable work of M. Dupin, entitled, *Voyages dans la Grande-Bretagne*.

This particular bell is of cast-iron, of a single piece, and has the form of a hat without the rim. Its length at the base is 6 feet, its breadth 3 feet 9 inches, and its height 4 feet 6 inches. In the upper parts are several circular holes, in which glass illuminators are fixed, and made perfectly air-tight. By means of them, vision is sufficiently distinct at four fathoms below the surface of the water, to execute any kind of labour with precision. In the interior of the bell, there are two benches, on which the workmen sit down; some ring-bolts at the sides, to which the tools are fastened by means of cords, so that if the workmen let them fall, they cannot be lost;—and also ring-bolts at the top, with ropes for fastening the things to be brought up to the surface.

Between the two rows of illuminators, is a strengthening piece of iron, perforated with two large holes, in which is fixed the ends of the chain for lowering or raising the diving-bell. Exactly in the centre is a small round opening, in which is screwed a copper rim fixed to the end of a leather tube, for introducing fresh air into the bell when it is below the surface of the water.

Dr. Halley, the great improver of the diving-bell, used to supply his machine with fresh air, by sending down casks, which, by means of cords, could be conducted under the bell, and there opened above the surface of the water. This was found, however, to be a very inconvenient plan, and the bell at Sheerness is supplied with air by means of a forcing-pump and a leather tube. A raft is kept as near to the bell as possible, and on it a small air-pump is worked, which, by means of the leather tube already mentioned, continually renews the air in the bell. This pump is composed of a short cylinder of a large diameter, and of a piston moved by a lever. The piston has six circular openings, shut up in the body of the pump by leather valves set in copper, which open to permit the entrance of the air when the piston is raised, and which shut when it is depressed. In order to prevent the reflux of the air introduced into the bell, there is a valve at the end of the tube which closes when the piston is raised, and opens when it is forced down. By this mode of renewing the air, the workmen can remain under water for hours together without any inconvenience.

In employing this diving-bell to build under water, the first proceeding is, to drive two parallel rows of piles, one inside, the other outside, of the space where the intended wall is to be built. Beams are fastened on the tops of the piles, both from pile to pile, in the same row, and transversely from one pile to the opposite pile in the parallel row. On these transverse beams planks are laid, which form a strong floor, and on the edges two bars of iron with teeth are fixed, so as to form an iron railway or road, the whole length of the platform.

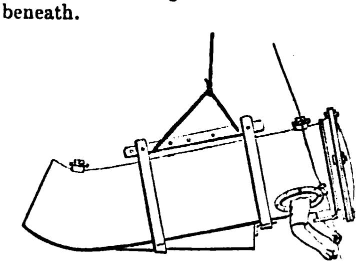
An uncovered waggon, the four wheels of which are teethed, so as to fit the teeth in these iron railways, is placed on them, and may be moved backwards and forwards along the line of the intended wall.

On the edges of this waggon, transversely with the line of the wall, other iron bars with teeth are fixed, with which the teeth in the four wheels of a second waggon correspond. The former waggon moves, therefore, along the line of the wall, while the latter moves on the former from side to side, or across the line of the wall. The tackle and ropes necessary for lowering or raising the bell, or the stones which are to be laid, are fixed to the second waggon. By the different movements of both the waggons, the bell can be carried to any and every point of the intended wall. Each of the waggons is moved by a double winch, on the axis of which are two pinion wheels, which work on two of the wheels of the waggons.

When it is intended to carry on the work, the stones ready prepared are suspended to the second waggon, and both are moved till each stone is over the place it is to occupy, and it is then lowered by a rope.

The people who descend under water in this machine, are said to feel at first a slight difficulty of breathing, attended with pain of the chest. On this, as well as on several other accounts, it is necessary to lower the bell very gradually and slowly. From being partly immersed in water, the workmen clothe themselves thickly and warmly; generally wearing the large boots, which scaffold men use. They also find it necessary to stuff their ears with cotton. On the whole, to descend frequently in the diving-bell, and to remain down long, is considered injurious to health; though the machine has not hitherto been sufficiently employed, to enable medical men to trace any particular disease which results from living under water.

It occasionally becomes necessary for the diver to proceed in a less cumbursome apparatus than the one we have now been describing. Such a machine is represented beneath.



It is supported by a chain or rope, and the diver is provided with a small cord shown in the engraving, by which his signals are made to the persons who have charge of the machine. An air-pump and pipe must be employed in this as well as in the former arrangement.

The large diving-bell has lately been used with great advantage in raising treasure from his Majesty's ship, Thetis, which was accomplished in a very tempestuous part of the ocean.

Divining Rod, is a rod made with certain superstitious ceremonies, either single and curved, or with two branches like a fork, of wood, brass, or other metal. The rod is held in a particular way, and if it bends towards one side, those who use the rod believe it to be an indication that there is treasure under the spot. Some publications respecting a man who, in quite recent times, pretended to be able to discover water and metals under the ground by his feelings, attracted much attention.

Divisibility. The actual subdivision of bodies has, in many cases, been carried to a prodigious extent. A slip of ivory, of an inch in length, is frequently divided into a hundred equal parts, which are distinctly visible. But, by the application of a very fine screw, 5000 equidistant lines, in the space of a quarter of an inch, can be traced on a surface of steel or glass with the fine point of a diamond, producing delicate iridescent colours. Common writing paper has a thickness of about the 500th part of an inch; but the pellicle separated from ox-gut, and then doubled to form gold-beaters' skin, is six times thinner.

A single pound of cotton has been spun into a thread 76 miles in length; and the same quantity of wool has been extended into a thread of 95 miles; the diameters of those threads being hence only the 350th and 400th part of an inch.

But the ductility of some metals far exceeds that of any other substance. The gold-beaters begin with a riband an inch broad and 150 inches long, which has been reduced, by passing through rollers, to about the 800th part of an inch in thickness. This riband is cut into squares, which are disposed between leaves of vellum, and beat by a heavy hammer, till they acquire a breadth of more than three inches, and are therefore extended ten times. These are again quartered, and placed between the folds of gold-beaters' skin, and stretched out, by the operation of a lighter hammer, to the breadth of five inches. The same process is repeated, sometimes more than once, by a succession of lighter hammers; so that 376 grains of gold are thus finally extended into 2000 leaves of 3.3 inches square, making in all 80 books, containing each 25 leaves. The metal is, consequently, reduced to the thinness of the 282,000th part of an inch, and every leaf weighs rather less than the 5th part of a grain. Silver is likewise capable of being laminated, but will scarcely bear an extension above half that of gold, or the 150,000th part of an inch thick. Copper and tin have still inferior degrees of ductility, and cannot, perhaps, be beat thinner than the 20,000th part of an inch. These form what is called *Dutch leaf*.

In the gilding of buttons, five grains of gold, which is applied as an amalgam with mercury, is allowed to each gross; so that the coating left must amount to the 110,000th part of an inch in thickness. If a piece of ivory or white satin be immersed in a nitro-muriate solution of gold, and then plunged into a jar of hydrogen gas, it will become covered with a surface of gold hardly exceeding in thickness the 10,000,000th part of an inch. The gilt wire used in embroidery is formed by extending gold over a surface of silver.

A silver rod, about two feet long, and an inch and a half in diameter, and weighing nearly 20 pounds, is richly coated with about 800 grains of pure gold. In England, the lowest proportion allowed is 100 grains of gold to a pound of silver. This gilt rod is then drawn through a series of diminishing holes, till it has stretched to the vast length of 240 miles, when the gold has, consequently, become attenuated 800 times, each grain covering a surface of 9600 square inches. This wire being now flatted, the golden film suffers a farther extension, and has its thickness reduced to the four or five millionth part of an inch. It has been asserted, that wires of pure gold can be drawn of only the 4000th part of an inch in diameter. But the late Dr. Wollaston, by an ingenious process, advanced much farther. Taking a short cylinder of silver, about the third part of an inch in diameter, he drilled a fine hole through its axis, and inserted a wire of platinum, only the 100th part of an inch thick. This silver mould was now drawn through the successive holes of a steel plate, till its diameter was brought to near the 1500th part of an inch, and, consequently, the internal wire being diminished in the same proportion, was reduced to between the four and five thousandth part of an inch. The compound wire was then dipped in warm nitric acid, which dissolved the silver, and left its core, or the wire of platinum. By passing the incrusted platinum through a greater number of holes, wires still finer were obtained, some of them only the 30,000th part of an inch in diameter. The tenacity of the metal, before reaching that limit, was considerable; a platinum wire of the 18,000th part of an inch in diameter, supporting the weight of one grain and a third. Such excessive fineness is hardly surpassed by the filamentous productions of nature. Human hair varies in thickness, from the 250th to the 600th part of an inch. The fibre ot the coarsest wool is about the 500th part of an inch in diameter, and that of the finest only the 1500th part.

The silk line, as spun by the worm, is about the 500th part of an inch thick; but a spider's line is, perhaps, six times finer, or only the 30,000th part of an inch in diameter; insomuch, that a single pound of this attenuated substance might be sufficient to encompass our globe. The red globules of the human blood have an irregular, roundish shape, from the 2500th to the 3300th of an inch in diameter, with a dark central spot. The trituration and levigation of powders, and the accidental abrasion and waste of the surface of solid bodies, occasion a disintegration of particles, almost exceeding the powers of computation.

Emery, after it has been ground, is thrown into a vat filled with water, and the fineness of the powder is distinguished by the time of its subsidence. In very dry situations, the dust lodged near the corners and crevices of ancient buildings is, by the continual agitation of the air, made to give a glossy polish to the interior side of the pillars and the less prominent parts of those venerable remains. So fine is the sand on the plains of Arabia, that it is carried sometimes 300 miles over the Mediterranean, by the sweeping sirocco. Along the shores of that sea, the rocks are covered by the pholas, a testaceous and edible worm, which, though very soft, yet, by unwearied perseverance, works a cylindrical hole into the heart of the hardest stone. The marble steps of the great churches in Italy are worn by the incessant crawling of abject devotees; nay, the hands and feet of bronze statues are, in the lapse of ages, wasted away by the ardent kisses of innumerable pilgrims that resort to those shrines. What an evanescent pellicle of the metal must be abraded at each successive contact! The solutions of certain saline bodies, and of other coloured substances, exhibit a prodigious subdivision and dissemination of matter.

A single grain of the sulphate of copper, or blue vitriol, will communicate a fine azure tint to five gallons of water. In this case, the copper must be attenuated at least ten million times; yet each drop of the liquid may contain as many coloured particles, distinguishable by our unassisted vision. A still minuter portion of cochineal, dissolved in deliquiate potash, will strike a bright purple colour through an equal mass of water. Odours are capable of a much wider diffusion. A single grain of musk has been known to perfume a large room for the space of 20 years. Consider how often, during that time, the air of the apartment must have been renewed, and have become charged with fresh odour! At the lowest computation, the musk had been subdivided into 320 quadrillions of particles, each of them capable of affecting the olfactory organs.

The vast diffusion of odorous effluvia may be conceived from the fact, that a lump of assafœtida, exposed to the open air, lost only a grain in seven weeks. Yet, since dogs hunt by the scent alone, the effluvia emitted from the several species of animals, and from different individuals of the same race, must be essentially distinct. The vapour of pestilence conveys its poison in a still more subtile and attenuated form. The seeds of contagion are known to lurk, for years, in various absorbent substances, which scatter death on exposure to the air. But the diffusion of the particles of light defies all powers of calculation.

A small taper will illuminate the atmosphere to the distance of four miles; yet the luminous particles, which fill that wide concavity, cannot amount to the 5000th part of a grain, which may be the whole consumption of the wax in light, smoke, and ashes. Animated matter likewise exhibits, in many instances, a wonderful subdivision. The milt of a codfish, when it begins to putrify, has been computed to contain a billion of perfect insects; so that thousands of these living creatures could be lifted on the point of a needle. But the infusory animalcules display, in their structure and functions, the most transcendant attenuation of matter. The *vibrio undula*, found in duck-weed, is computed to be ten thousand million times smaller than a hemp seed. The *vibrio lineola* occurs in vegetable infusions, every drop containing myriads of those oblong points. Of the *monas gelatinosa*, discovered in ditch water, millions appear in the field of a microscope, playing, like the sunbeams, in a single drop of liquid. Insects have been discovered so small as not to exceed the 10,000th part of an inch, so that 1,000,000,000,000 of them might be contained within the space of one cubic inch; yet each animalcule must consist of parts connected with each other, with vessels, with fluids, and with organs necessary for its motions, for its increase, for its propagation, &c. How inconceivably small must those organs be! and yet they are, unquestionably, composed of other parts still smaller, and still farther removed from the perception of our senses.

Division. At the conclusion of the article **Algebra** we referred to this head for one or two examples of a peculiar character. The first we shall give is of frequent application; it is the division of a^m-b^m by $a-b$ without remainder, and is remarkable for the mode of reasoning necessary to effect it.

We have already seen that the product of $a+b$ by $a-b$ is a^2-b^2; consequently a^2-b^2 divided by $a-b$ gives $a+b$ as quotient. Similarly we find that a^3-b^3 divided by $a-b$ gives the quotient a^2+ab+b^2; and that a^4-b^4 divided by $a-b$ gives that of $a^3+a^2b+ab^2+b^3$. Speaking generally, then, a^2-b^2, a^3-b^3, and a^4-b^4 are each severally divisible without remainder by $a-b$. This we ascertain to be a fact by actually performing the division; and if we were to make the trial, we should also find that a^5-b^5, a^6-b^6, a^7-b^7 were each divisible exactly by $a-b$. Reasoning then from analogy, we might conclude that whatever was the exponent of the two letters a and b, their difference would always be divisible by $a-b$ without remainder. But analogy is not sufficient to authorise the assertion of such a fact; we must have proof, and this may be obtained in the following manner:

Let us call the exponent m, and try to divide a^m-b^m by $a-b$.

We have then, according to the rules of division,

$$\begin{array}{rl} a^m-b^m & \big\rangle\ a-b. \\ \text{1st. Remainder: . . . . . } +a^{m-1}b-b^m & \big\rangle\ a^{m-1}. \end{array}$$

Dividing a^m by a, we obtain a^{m-1} for the first term of the quotient, and have a remainder $a^{m-1}b-b^m$, which may be put under the form of $a^{m-1}\times b-b^{m-1}\times b$, or $b\,(a^{m-1}-b^{m-1})$. Now the exact divisibility of a^m-b^m by $a-b$, depends of course upon whether this remainder is divisible exactly by $a-b$; in other words, if $b(a^{m-1}-b^{m-1})$ be so divisible, then a^m-b^m is. But if we examine the remainder, we shall perceive that it is merely b multiplied by the difference of a and b, each of these two letters being raised to a power one degree lower than in the original dividend a^m-b^m. If, then, $a^{m-1}-b^{m-1}$ be exactly divisible by $a-b$, a^m-b^m is so also. In other words, if the difference of two numbers, each of which is raised to a *certain power*, be exactly divisible by the difference of those numbers, then their difference, when each is raised to a *power of one degree greater* is also divisible by that difference without remainder. But a^2-b^2 is exactly divisible by $a-b$; and the operation gives the quotient $a+b$. Consequently a^3-b^3 is so divisible also; the quotient being $a^2+b\left(\dfrac{a^2-b^2}{a-b}\right)$ or $a^2+b(a+b$ or a^2+ab+b^2. Similarly $\left(\dfrac{a^4-b^4}{a-b}\right)$ gives without remainder the quotient $a^3+b\left(\dfrac{a^3-b^3}{a-b}\right)$, or $a^3+b\,(a^2+ab+b^2)$, or $a^3+a^2b+ab^2+b^3$; and generally $\dfrac{a^m-b}{a-b}$ gives without remainder the whole quotient $a^{m-1}+a^{m-2}b+a^{m-3}b^2 \ldots\ldots\ldots +ab^{m-2}+b^{\;-1}$.

The method of reasoning just adopted in the proof of the proposition of the divisibility without remainder of a^m-b^m by $a-b$ is of very frequent occurrence in algebra, and should be well comprehended by the student. It is a species of induction, and forms one of the most powerful engines of demonstration which the mathematician possesses.

Let it be proposed to divide 1 by $1+x$.

$$\begin{array}{l|l} 1 & 1+x \\ \underline{1+x} & \overline{1-x+x^2-x^3+,\ \text{\&c.}} \\ -x & \\ \underline{-x-x^2} & \\ \quad x^2 & \\ \quad \underline{x^2+x^3} & \\ \quad -x^3 & \end{array}$$

The division it is evident will never end, and we have then

$$\frac{1}{1+x}=1-x+x^2-x^3+x^4-,\ \text{\&c.}$$

Now, as x stands for no particular number, the above result is true, when it is replaced by any, whatsoever. Put 1 for it, and we have

$$\frac{1}{2}=1-1+1-1+1-1+1,\ \text{\&c.}$$

This result was a source of embarrassment to some mathematicians who, thinking that the &c. must comprise a set of terms exactly the same as those that go before it, could not understand how a series of numbers which when added together is alternately 0 or 1, can ever be equal to $\frac{1}{2}$. If the remainder however be taken into account, the result is perfectly intelligible; for that remainder is always some power of x, and, divided by $1+x$, it becomes in the case of $x=1$, $\frac{1}{1+1}$, or $\frac{1}{2}$; and we have

$$\frac{1}{2}=1-1+1-1+1-1+\frac{1}{2};$$

or,

$$\frac{1}{2}=1-1+1-1+1-1+1-\frac{1}{2}$$

both of which are perfectly correct.

The following examples will be useful exercises; observing that $2n$ is merely intended as the general representative of every exponent which is an even number; for n may be either even or odd, but $2n$ (always premising that n is whole) must of necessity be even, or capable of being divided by 2 and leaving a whole number for quotient; and $2n+1$ must be odd. The possibility of performing the following divisions without having any remainder left, and the certainty of obtaining the quotients marked down, is to be proved.

$$\frac{an-1}{a-1}=a^{n-1}+a^{n-2}+\ldots\ldots\ldots+a+1$$

$$\frac{a^{2n+1}+1}{a+1}=a^{2n}-a^{2n-1}+\ldots\ldots\ldots+a^2-a+1$$

$$\frac{a2n-1}{a+1}=a^{2n-1}-a^{2n-2}+\ldots\ldots\ldots-a2+a-1$$

Docks. The word *dock* was formerly applied to the slip or excavation made for the purpose of building or repairing a vessel; and was distinguished as a *dry dock* when furnished with flood-gates to prevent the influx of the tide, if required; and as a *wet dock* when, having no flood-gates, the vessel could only be cleaned or repaired during the period in which the tide left her accessible. These slips or docks are still used. At present, the name of *graving*

or *building dock* is more generally given to what we have termed *dry dock*, which latter term is applied to those docks or basins left dry by the tide; while the appellation of *slip* is confined to the narrow inlet for building or repairing, unprotected by gates.

During the growth of the maritime power and the commerce of Europe, it was found highly inconvenient to load and unload vessels in a tide-river or in a harbour not entirely land-locked; for either the ships could not be brought close to the wharfs, or, when conducted there at the flood of the tide, they were left dry at the ebb, and suffered considerable damage by straining, by delay from neap tides, and other accidents and inconveniences. To obviate these inconveniences, improvements in the existing docks or slips were made from time to time, until England, taking the lead, introduced a system of floating docks, which have greatly contributed to her advancement and prosperity.

Many of the principal maritime ports of Europe are provided with dry docks for building and repairing vessels; and of these, Toulon, Havre, and Brest, have the most remarkable. Most seaport towns are provided with graving docks for the repairing of ships; but it is only in the British islands that the system has been carried to any extent of forming large basins or floating docks, furnished with floodgates for the reception of shipping to load and unload, wherein the vessel remains safe at the quay-side. The docks of Liverpool were the first constructed in England; and many other maritime powers have been induced to follow her example. It is scarcely fifty years since nearly the whole of the vessels that entered the port of London were obliged to remain moored in the open stream of the Thames.

The example which Liverpool had set for nearly a century, pointed out the remedy for the existing evils, and the constructing of floating docks in the port of London was resolved on. The first constructed, and those nearest the trading part of the metropolis, are called the *London Docks*. They are below the site of the Tower, and on the left bank of the Thames; were begun in 1800, and completed in 1805. The dock, properly so called, is 420 yards in length, 276 yards in breadth, and 29 feet in depth; its superficies are equal to 25 acres; that of the basin communicating with it is above 2½ acres; and, including the ground occupied by warehouses, sheds, and quays, the whole premises contain a superficies of 110 acres. Excepting those ships that trade to the East and West Indies, every vessel, whether English or foreign, may enter the London Dock upon paying the duties, to unship her cargo, or take in a new lading.

For the convenience of business, ranges of sheds, low, and of a very simple construction, have been erected along the sides of the dock, and near the edges of the quays, into which cargoes are removed. Behind these sheds, and in a parallel direction to them, stands a line of magnificent warehouses, four stories high, with spacious vaults, into which the casks are conveyed by inclined planes. These buildings occupy a superficies of 120,000 square yards. The cellars are appropriated to wines and brandies, and railways, or rather tramways, running in all directions, facilitate labour. The London Docks have their several parts perfectly adapted to each other, and are of the most admirable construction. The gates, like all those whose size much exceeds 20 feet, instead of being straight, are curved on the side on which the water presses.

The *West India Docks* are on the left bank of the Thames, at the distance of about one mile and a half below the London Docks. They are situated on the base of a tongue of land of the Isle of Dogs—a sort of peninsula formed by a long circuit of the river. The West India Docks are much superior to the London, both in extent and regularity. These vast works were undertaken and executed by an association of private individuals, and by means of a mere subscription. Twenty-seven months sufficed to accomplish the whole. The excavations of the West India Docks were begun on the 12th of July, 1800; and as early as the month of September, 1802, vessels entered the import dock! At the highest tides, the depth of water in the two docks is 24 feet; they are formed parallel to each other; their common length is about 890 yards. The largest, which has a superficies of about 30 acres, is destined for those vessels returning to the West Indies, which deposit their cargoes in the warehouses of this artificial port. The second, the superficies of which is about 25 acres, receives the vessels laid up in ordinary, or taking the outward-bound cargoes.

These docks, with their basins, and the locks which connect them with the river, present an area of 68 acres of ground, excavated by human hands, for the reception and moorage of vessels. The total superficies, including that of the quays and warehouses, is 140 acres. During the busy season, this establishment employs about 3000 workmen. It can admit, at the same time, 204 vessels in the import, and 195 in the export dock, forming a total of 120,000 tons. During the first 15 years, 7260 vessels entered them. Upon the quays, under the sheds, and in the warehouses, there have been deposited, at the same time, 148,563 barrels or casks of sugar, 70,875 barrels, and 433,648 bags of coffee, 35,158 pipes of rum and Madeira wine, 14,021 logs of mahogany, 21,350 tons of logwood, &c. At the upper and lower entrances of the two docks, a basin presents three locks of communication. The first communicates with the Thames; the water is kept in it by means of double gates. The second and third locks lead respectively into the export and import docks; they have also double gates. By this means, the vessels are able to come in and go out independently of the state of the tide; they may remain in the basin as long as is judged convenient. The water of the docks being but very little higher than that of the basins, it does not press violently on the gates of the locks. It should be also observed, that this water having had time to settle in its previous passage through the basin, hardly deposits any sediment when introduced into the docks. The *East India Docks*, belonging to the East India Company, are inferior to the West India Docks in magnitude, but equal in point of construction and security of property. Having to receive vessels of 2500 tons, they are deeper than the West India Docks, and have never less than 23 or 24 feet water.

The docks erected on the site of St. Katherine's Church, near the Tower of London, are also works of great magnitude; though they do not materially differ from those already described.

DOG-BANE contains a bitter extractive principle, soluble in water and alcohol, a colouring principle soluble in water only, a very large quantity of caout-

chouc, and a volatile oil.—It is a very active plant, highly valued by the American Indians. The root is the most powerful part, and is much employed by the physicians of that country instead of ipecacuanha. Thirty grains of the recently powdered root evacuate the stomach as effectually as two-thirds of this quantity of ipecacuanha, by which name it is known in various parts of the Eastern States of America. Its power is diminished by keeping, and destroyed by age. It is given in small doses as a tonic medicine.

DOG-DAYS. This name is applied to the period between the 24th July and 24th August, because the dog-star (Sirius), during this period, rises with the sun. The heat, which is usually most oppressive at this season, was formerly ascribed to the conjunction of this star with the sun.

DOGGER; a Dutch vessel navigated in the German Ocean; it is equipped with two masts, a main and a mizzen-mast, and somewhat resembles a ketch. It is principally used for fishing on the Dogger Bank.

DOG-GRASS. This root is much used in medicine. Among the demulcent substances, dog-grass is one of the most frequently employed in France. It is used in most of the inflammatory and febrile diseases, and especially in those of the urinary passages. It was formerly recommended as a powerful diuretic, and was employed as such in dropsies: but we know, at present, this opinion to be erroneous.

DOG-STAR; Sirius; the star that gives their name to the dog-days.

DOG-WOOD. The bark of this tree, as well as that of several other species of cornus inhabiting Canada and the Northern States, possesses similar properties with the Peruvian bark, and is employed successfully in the cure of intermittent fevers. The bark of the root, stem, and branches tastes very much like this famous bark; it is bitter, astringent, and slightly aromatic. Its astringency is, however, stronger than that of Peruvian bark. This bark is, without doubt, one of the most valuable native medicines. As a substitute for the Peruvian bark, much has been written in commendation of it. The resemblance extends to its chemical and physical, as well as therapeutical properties. The bark of the dog-wood is extensively employed by American practitioners in intermittent fevers, and the report they give of it is very favourable and satisfactory. It is remarked that, in its recent state, it is apt to disagree with the stomach, and to produce pains in the bowels; but, in order to prevent this effect, it is simply needful to add to it, when used, a few drops of laudanum, or to use the bark after it has been collected for some time. This bark may be used with still greater advantage in intermittents, if combined with serpentaria.

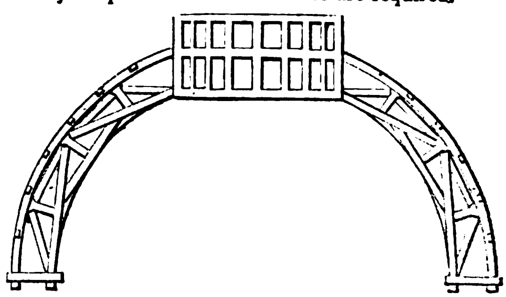
DOIT was the ancient Scottish penny-piece, of which twelve were equal to a penny sterling. Two of them were equal to the bodle, six to the baubee, and eight to the acheson. There was also in Lower Germany a small coin called *deut* (pronounced like *doit*) and *dütchen*, the diminutive of *deut*. In the Netherlands, the coin is called *dayt*, and Frisch believes that these words took their origin from the French *tête*, head; the piece of 20 kreuzer is still called, in Germany, *kopstück* (head-piece).

DOLLAR; a coin differing in its value. This word corresponds to the German *thaler*, the Low-German *dahler*, the Danish *daler*, the Italian *tallero*. All these words, together with our *dollar*, are derived from the name of the Bohemian town *Joachims-Thal* (Joachim's Valley), where in 1518, the Count of Schlick coined silver pieces of an ounce weight. These, indeed, were not the first of the kind coined; yet, as they were numerous and very good, they became generally known by the name of *Joachimsthaler*, which is the German adjective of *Joachimsthal*, and also *Schlickenthaler*, from the name of the counts. As these coins were in good repute, *thalers* were also coined in other countries, but of different value: thus originated the *laub-thaler* (leaf-dollar) *Philipps-thaler*, the Swedish copper dollar, &c. In Russia, a dollar is called *jephimock*, from *Joachim*.

DOLOMITE, in *mineralogy*. See NATURAL HISTORY Division.

DOME, in *architecture*. Some of the greatest engineers both in this country and Italy, have given their particular attention to this branch of building. Michael Angelo and Sir Christopher Wren have executed the finest in Europe.

The frame-work intended to support a simple dome, in which neither masonry or brick-work are employed, is shown beneath; but that arrangement is only adopted when small domes are required.

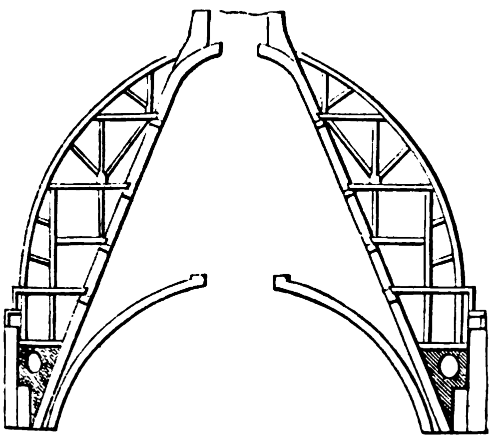


The construction of a dome is less difficult than that of an arch, since the tendency of each part to fall is counteracted, not only by the pressure of the parts above and below, but also by the resistance of those which are situated on each side. A dome may therefore be erected without any temporary support, like the centre which is required for the construction of an arch; and it may at last be left open at the summit, without standing in need of a keystone, since the pressure of the lower parts is sufficiently resisted by the collateral parts of the same horizontal tier, to prevent the possibility of their falling in, or of their forcing out the upper parts. The weight of the dome may, however, force out its lower parts, if it rises in a direction too nearly vertical; and supposing its form spherical, and its thickness equal, it will require to be confined by a hoop or chain as soon as the span becomes eleven-fourteenths of the whole diameter. But if the thickness of the dome be diminished as it rises, it will not require to be bound so high: thus, if the increase of thickness in descending begin at about thirty degrees from the summit, and be continued until at about sixty degrees, the dome becomes little more than twice as thick as at first, the equilibrium will be so far secure; and at this distance it would be proper to employ either a chain, or some external pressure, to prove the stability, since the weight itself would require to be increased without limit, if it were the only source of pressure on the lower parts.

The dome of the Pantheon at Rome is nearly circular, and its lower parts are so much thicker than

its upper parts, as to afford a sufficient resistance to their pressure: they are supported by walls of great thickness, and furnished with many projections which answer the purpose of abutments and buttresses.

The dome of St. Paul's is justly considered as a master-piece of architectural skill; but even with all its excellence and scientific arrangement, Sir Christopher Wren found it necessary to bind in the masonry by a vast connected link of iron. The interior cone of brick-work on which depends the internal frame-work is shown in the section.



Dominical Letter, in the calculation of time, properly called *Sunday letter;* one of the seven letters of the alphabet, A B C D E F G, used in almanacs, ephemerides, &c., to designate the Sundays throughout the year. In our almanacs, the first seven letters of the alphabet are commonly placed to show on what days of the week, the days of the month, fall throughout the year. And because one of those seven letters must necessarily stand against Sunday, it is printed in a capital form, and called the *dominical letter;* the other six being inserted in different characters, to denote the other six days of the week. Now, since a common Julian year contains 365 days, if this number be divided by 7 (the number of days in a week), there will remain one day. If there had been no remainder, it is obvious the year would constantly begin on the same day of the week; but, since one remains, it is plain that the year must begin and end on the same day of the week; and therefore the next year will begin on the day following. Hence, when January begins on Sunday, A is the dominical or Sunday letter for that year: then, because the next year begins on Monday, the Sunday will fall on the seventh day, to which is annexed the seventh letter, G, which, therefore, will be the dominical letter for all that year: and as the third year will begin on Tuesday, the Sunday will fall on the sixth day; therefore F will be the Sunday letter for that year. Whence it is evident, that the Sunday letters will go annually in retrograde order, thus, G, F, E, D, C, B, A; and in the course of seven years, if they were all common ones, the same days of the week and dominical letters would return to the same days of the months. But, because there are 366 days in a leap-year, if the number be divided by 7, there will remain two days over and above the 52 weeks, of which the year consists. And, therefore, if the leap-year begins on Sunday, it will end on Monday; and as the year will begin on Tuesday, the first Sunday thereof must fall on the 6th of January, to which is annexed the letter F, and not G, as in common years.

By this means, the leap-year returning every fourth year, the order of the dominical letters is interrupted, and the series cannot return to its first state till after four times seven, or 28 years; and then the same days of the months return in order, to the same days of the week as before.

The dominical letter may be found universally, for any year of any century, thus: Divide the centuries by 4, and take twice what remains from 6; then add the remainder to the odd years, above the even centuries, and their 4th. Divide their sum by 7, and the remainder taken from 7, will leave the number answering to the letter required. Thus, for the year 1878, the letter is F. For the centuries, 18, divided by 4, leave 2; the double of which, taken from 6, leaves 2 again; to which add the odd years, 78, and their 4th part, 19, the sum, 99, divided by 7, leaves 1, which, taken from 7, leaves 6, answering to F, the sixth letter in the alphabet.

Donjon, in *fortification,* signifies a strong tower or redoubt, into which the garrison of an ancient fortress could retreat in case of necessity. The donjon keep was more common in Scottish than in English fortresses.

Dormant state of animals. We are all accustomed to see a large part of creation, during summer, in great activity, and in winter returning to an apparently inanimate state: we mean the plants; but this phenomenon is not common in the case of animals. There is, however, a small number of animals, which, besides the daily rest that they have in common with most other animals, remain, during some months in the year, in an apparently lifeless state; at least, in utter inactivity. Except the hedgehog and the bat, all the *mammalia* subject to this dormant state, belong to the class of digitated animals. They are found not only in cold climates, but in very warm ones; for instance, the jerboa, in Arabia, and the taurick, in Madagascar. The period of long sleep generally begins when the food of the animal begins to become scarce, and inactivity spreads over the vegetable kingdom. Instinct, at this time, impels the animals to seek a safe place for their period of rest. The bat hides itself in dark caves, or in walls of decayed buildings.

The hedgehog envelopes himself in leaves, and generally conceals himself in fern-brakes. Hamsters and marmots bury themselves in the ground, and the jumping-mouse of Canada and the United States encloses itself in a ball of clay. At the same time, these singular animals roll themselves together in such a way that the extremities are protected against cold, and the abdominal intestines, and even the windpipe, are compressed, so that the circulation of the blood is checked. Many of them, especially the gnawers, as the hamster and Norway rat, collect, previously to their period of sleep, considerable stores of food, on which they probably live until sleep overpowers them. In this period we observe in the animals, first, a decrease of animal heat, which, in the case of some, is diminished 20°, with others 40° to 50° Fahrenheit; yet it is always higher than the temperature of the atmosphere in the winter months. If these animals are waked during winter, they soon recover their

natural warmth, and this artificial waking does not injure them.

Secondly, animals in a dormant state, breathe much slower and more interruptedly than at other times. Some will remain even a quarter of an hour without any respiration; and animals in this state seldom breathe more than once in a minute. Hence they corrupt the surrounding air much less than if their respiration was free. Of course, the heart moves proportionally slow. With the hamster, it only beats 15 times a minute, whilst, in a working state, it beats 115 times a minute. The irritability of the animals is very low; and hamsters in this state have been dissected, which only now and then gasped for air, or, at least, opened the mouth; and on which sulphuric acid, put on their intestines, had little or no effect.

Marmots can be awakened only by powerful electric shocks. The digestion is also diminished; the stomach and intestines are usually empty; and, even if the animals are awakened, they do not manifest symptoms of appetite, except in heated rooms.

The causes of the dormant state of animals have generally been sought in a peculiar construction of the organs. It is true, that the veins in such animals are usually much wider and larger than in others; hence the arteries can exert comparatively little activity. The great *vena cava* also not merely opens into the right auricle of the heart, but divides itself into two considerable branches; and the thymus gland, which in the fœtus is so large, is also very extensive in this species of animals. The immediate cause, however, producing this torpidity, is mostly, if not entirely, the cold. The animals of this species fall into this sleep in the middle of summer, if they are exposed to a cold temperature; on the other hand, they remain awake during the winter, if they are brought, towards autumn, into a warm room. Yet they fall asleep if the heating of the room is discontinued for some time. In the case of some of them, confined air produces the sleep; thus a hamster may be made to sleep very easily if it is put into a vessel which is buried deep under ground.

Among the birds, some of the swallows are subject to a similar sleep. The swift (*hirundo apus*) is not only found in the crevices of walls, but also in morasses, in a dormant state, during winter; and many have concluded from this that all swallows pass the winter in this state, which is incorrect, as they are known to be birds of passage. Most probably those swallows which have been found in a dormant state, were prevented from emigrating by accident, and became torpid in their retreat, through cold. In a similar way, young cuckoos have been found torpid in the water, though this state is by no means natural to them. With frogs and other amphibious reptiles, the dormant state is very common. As soon as the temperature of the atmosphere sinks under 50° Fah., the number of pulsations of the heart is diminished from 30 to 12 in a minute. If, in this state, food is put into the stomach by force, it remains undigested for a long time. Frogs, serpents, and lizards, kept in artificial cold, may remain for years in this state: hence they have been sometimes found enclosed in stones, in which they have been, perhaps, for centuries. The other lower animals, as snails, insects, &c., are also subject to a similar torpidity. A state of partial torpor takes place in the case of the common bear and the raccoon. The bear begins to be drowsy in November, when he is particularly fat, and retires into his den, which he has lined with moss, and where he but rarely awakes in winter. When he does awake, he is accustomed to lick his paws, which are without hair, and full of small glands; hence the belief that he draws his nourishment only from them. The badger also sleeps the greater part of the winter.

DOUBLING a cape, is to sail round or pass beyond it, so that the point of land shall separate the ship from her former situation, or lie between her and any distant observer.

DOUBLING upon, in a naval engagement; the act of enclosing any part of a hostile fleet between two fires, or of cannonading it on both sides. It is usually performed by the van or rear of the fleet which is superior in number, taking the advantage of the wind, or of its situation and circumstances, and tacking or running round the van or rear of the enemy, who are thereby exposed to great danger.

DOUBLOON; a Spanish coin of the value of two pistoles. (See COIN.)

DOVE-TAILING, in *carpentry*, is the fastening boards together, by letting one piece into another, in the form of the tail of a dove. The dove-tail is the strongest of jointings, because the tenon, or piece of wood which is put into the other, goes widening to the end, so that it cannot be drawn out again.

DOVE-TAIL JOINT, in *anatomy*. This beautiful mode of uniting osseus bodies occurs in various parts of the body; and it is most probable that on that natural species of structure, the carpenter has founded his mechanical process.

DRACHM, the unit of weight and of money among the ancient Greeks, both as a weight and a coin contained six oboli, and was itself the 100th part of a mina, and the 6000th part of a talent. 1. According to the calculations of Wurm, the weight of the Attic drachm is 67.383 grains English Troy weight, and the Attic talent 70 lbs. 6½ oz. The calculation of M. Letronne differs slightly from this. There were several other kinds of drachm and talent in use those of Ægina were the heaviest, the Æginetic talent being equal to 1,000 Attic drachms; the Euboic talent was nearly the same as the Attic; the Rhodian and Egyptian talents were each about one-third of the Attic. Whenever no particular kind is designated, the Attic talent is meant. 2. The principal Grecian coin was the drachm: it was of silver: it was divided, like the weight, into six oboli (silver). The tetradrachm (of four drachms) was called the *stater*. These coins differed much in value in different countries in Greece, and in different ages in the same country. The Attic drachm and stater occur most frequently.

Besides these silver coins, there were also the stater of gold, equal in value to 20 drachms, and the talent of gold, which was used sometimes to designate a quantity of gold equal in *value*, sometimes a quantity of gold equal in *weight*, to the silver talent. It sometimes, also, designates a gold coin, weighing six drachms. In the time of Solon, a sheep could be bought for one drachm, an ox for five. In the time of Demosthenes, a fat ox cost 80 drachms, a lamb, 10.

DRACUNCULI, in *medicine;* small, long worms which breed in the muscular parts of the arms and legs, called Guinea worms, common among the natives of Guinea. The worm is white, round and uniform, resembling white, round tape. It is lodged

between the interstices and membranes of the muscles, where it insinuates itself, sometimes exceeding five ells in length. It occasions no great pain in the beginning; but, at such times as it is ready to go out, the part adjoining to the extremity of the worm, where it attempts its exit, begins to swell, throb, and become inflamed: this generally happens about the ankle, leg, or thigh, and rarely higher. The countries where this distemper is observed are hot and sultry, subject to great droughts, and the inhabitants make use of stagnating and corrupted water, in which it is very probable that the ova of these animalculæ may be contained; for the white people who drink this water are liable to the disease as well as the Negroes.

Drag; a machine employed to search for drowned persons.

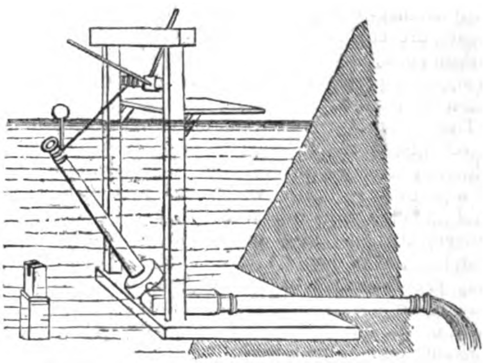
Dragon, in *astronomy*; one of the northern constellations.

Dragon's Blood; a resinous juice, obtained from several plants by incision. It is often very much adulterated, and other substances are substituted; particularly gum Arabic, and gum Senegal, coloured with logwood, &c. Several of these substances may be detected by their dissolving in water, while dragon's blood is nearly insoluble; others require to be submitted to some chemical tests. Madagascar furnishes this resin of a good quality, but so much mixed with foreign substances, that it is little used. Dragon's blood is opaque, of a deep reddish-brown colour, brittle, and has a smooth and shining conchoidal fracture; when in thin laminæ, it is sometimes transparent; when burnt, it gives out an odour somewhat analogous to benzoin; its taste is a little astringent; it is soluble in alcohol, and the solution will permanently stain heated marble, for which purpose it is often used, as well as for staining leather and wood. It is also soluble in oil, and enters into the composition of a very brilliant varnish, which is much esteemed by artists. Its quality may be proved by making marks on paper: the best leaves a fine red trace, and commands a pretty high price. It was formerly in high repute as a medicine, but at the present time is very little used. An astringent resin, obtained from the *eucalyptus resinifera* of New Holland, bears the name of *dragon's blood* in the English settlements in that country.

Dragoon; a kind of light-horseman, of French origin, trained to fight either in or out of the line, in a body, or singly, chiefly on horseback, but if necessary, on foot also. The dragoons were mounted, armed, and exercised as these objects require. They probably took the name of dragoons from the Roman *draconaris*, whose lances were adorned with figures of dragons. Experience proving that they did not answer the end designed, they were hardly ever used in infantry service, and now form a useful kind of cavalry, mounted on horses too heavy for the hussars, and too light for cuirassiers.

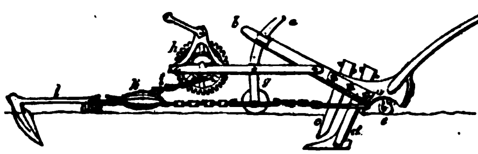
Draining. The inconvenience of an over-moist soil is but little felt in the neighbourhood of the British metropolis. There are, however, many parts of England in which draining becomes a most important desideratum. The first thing to be attended to, is the elevation of the part to be drained: and as in large drains it becomes necessary to keep the channels themselves open, it is adviseable to employ an apparatus similar to that represented in the annexed engraving, to accomplish this object.

Now, if we suppose the place to be drained situated in the neighbourhood of the sea, it will not be adviseable to admit a free communication at all times; but it requires a free passage of water at stated periods, for the purpose of cleansing the drain, and at different heights. The diagonal tube supported by the rope coiled round the cylinder, may be readily placed at any required angle. When we wish the water in the drain not to exceed a certain height, we have only to regulate the winch accordingly.



We have thus briefly noticed the drain on a large scale. A very simple mode of draining land, which is wet merely from the retentive nature of the soil, and which has been practised with success, consists in adding to the felly of a six-inch cart wheel, a piece of wood, upon which is a triangular rim of iron. That side of the cart containing this prepared wheel, is then loaded, till the piece of iron indents the soil to the depth of six or eight inches. These furrows are made in lines from five to ten yards asunder, the grass is merely pressed down, and not destroyed, and they generally grow up in the course of the year. They should, therefore, be made annually, at the approach of winter; but the work is so easily executed, that a single person, with two old horses, will go over from ten to twenty acres in eight hours.

Draining Plough. This is a very important agricultural implement, of which we give a diagram.



We may suppose a case in which its powers would be indispensable. It becomes necessary to cut a trench for the passage of water; and the furrow being too deep for the common process, the anchor or hook, *l*, is inserted in the ground. We have thus a fixed point for resisting the action of the pulley, *k*. If power be now applied to the handle at top, it communicates motion to the wheel, *h*, with an enormous increase of power, and the acting portions of the plough, *c d*, are forced through the soil. The arrangement at *a b c*, enables the conductor to give the required depth to the furrow. It will be obvious that the pulley, *g*, by resting on the ground, tends to diminish friction.

Draught; the depth of a body of water necessary to float a ship; hence a ship is said to draw so many feet of water, when she is borne up by a column of water, of that particular depth; for instance, if she requires a body of water, whose depth is equal to twelve feet, to float or buoy up a ship on its surface, she is said to draw 12 feet of water; and, that this draught may be more readily known, the feet are marked on the stem, and stern post, from the keel upwards.

Draughts; a game played on a chequered board, with twenty-four pieces, which by angular movements, are enabled to take each other, according to certain rules, until one of the parties has lost all his men, or is placed in a situation to lose them all, when the game is at an end.

Drawback, in *commerce;* an allowance made to merchants, on the re-exportation of certain goods; which in some cases consists of the whole, in others of a part of the duties, which had previously been paid upon the importation. A still more equitable arrangement than that of drawbacks, is, to allow the merchant, who imports any commodity, which he may probably wish to export again, to deposit it in the public warehouses, giving a bond for the payment of the duties, should he dispose of it for home consumption. This is called *bonding,* and is allowed to a considerable extent in this country.

Drawing, considered as a distinct branch of art, is the elder sister of painting, and in the course of time became connected with geometry. It is the art of representing by means of lines upon a flat surface, the forms of objects, and their positions and relations. The attempt to imitate, by lines, the forms which we see in nature, is the commencement of all drawing. According to a Greek tradition, drawing and sculpture took their rise together, when the daughter of Dibutades drew the outline of the shadow of her lover upon the wall, which her father cut out and modelled in clay. We can distinguish, in the earliest attempts at drawing, different epochs, which are found in almost all nations:—1. Objects were delineated only with rude, shapeless lines. 2. In order to make such drawings more striking to the eye, the sketch was filled up with black, or some other colour, and then the eyes, eyebrows, nose, mouth, and hair were marked with white upon the dark surface. To all these figures the name was attached, and in general, explanatory words, such as we find upon all the old vases.

This custom was continued by the Greeks, even in the most flourishing period of the art of drawing among them; for the figures of the great picture of Polygnotus, at Delphi, were designated by such inscriptions. In the 3rd epoch, an attempt was made to give animation to pictures, by representing the different colours of the drapery; but, as yet there was no attempt at perspective. In this manner Helen and Andromache embroidered tapestry, as described in the poems of Homer. In the 4th period, the want of prominence in the figures was remarked. Ardices and Telephanes (probably fictitious names) began, by drawing lines in the back-ground, to produce the appearance of shadow, and to give prominence to their figures. In later times, Polidoro di Caravaggio delineated in this way many frescoes in Rome, where he used only a single colour, but produced the shading by lines drawn thus, in the manner called *hatching.* These works are called *al sgrafito* or *peindures hachées.* This manner of drawing, however, was very hard. Philocles and Cleanthes invented the *monochrome,* or picture with one colour. In the *monochrome,* the colour used was mixed with white, so that this resembled the style now called *en camayeu.* This was the first step from drawing to proper painting, which is distinguished by having the back-ground of the picture filled.

The Greeks were very careful and particular in their instruction in drawing. Pamphilus, the teacher of Apelles, wished his pupils to remain with him ten years. There were three stages of instruction: in the first, firmness of hand and of stroke was obtained, and the learners drew with styles upon tablets covered with wax; in the second, fineness and delicacy of stroke was studied, while the learner laboured with the style upon smooth tablets, made of box-wood, and sometimes upon membranes, or upon the skins of wild beasts, properly prepared, and covered with wax. In the third stage, freedom and ease were to be acquired; here the pencil was used instead of the style, and with it black or red sketches were drawn upon white tablets, or white sketches upon black tablets. The tablets used were covered either with chalk or gypsum.

Line-drawing was carried to the highest perfection, and was the glory of the greatest masters. The rivalship of Apelles and Protogenes in such lines, drawn with distinguished delicacy and skill, and displaying a master's hand, is well known. This fineness and clearness of outline is also the chief merit of the celebrated vase painters. Something hard and dry was found in the pictures executed on such outlines, and it may well be maintained that this manner of drawing, through the influence of the Byzantine school on the west of Europe, gave rise to the dry and meagre style of the old Italian as well as of the old Dutch school.

When we consider the art of drawing as it exists at the present time, we perceive that there are three distinct kinds of drawing—with the pen, with crayons, and with Indian ink, or similar substances. Artists sometimes employ coloured and sometimes white paper; in the former case, the lights are produced by white crayons; but in the latter case, they are produced by leaving the paper uncovered. The drawings with the pen have always something hard and disagreeable, yet they give steadiness and ease to the hand, and are peculiarly serviceable to landscape painters. There are two different ways of drawing with the pen; either the drawing is darkened on the shaded side with lines, or the outline only is given by the pen, and the shades are delicately touched in with Indian ink.

This mode is peculiarly adapted to architectural drawings. The crayon drawings are the most common, and the most suitable for beginners, because any faults can be effaced or covered over. Artists make use of black, as well as of red crayons; and, when the ground is coloured, they produce the light by means of white crayons. If the crayon is scraped, and the powder rubbed in with little rolls of paper or leather, the drawing becomes exceedingly delicate and agreeable, though its outline is deficient in strict precision. This manner, which from the French name of the rolls used, is also called *à l'estompe,* is peculiarly suitable for large masses, and shades, and *chiaro-scuro,* and for producing a harmonious effect of light. There are also crayon drawings, where the

principal colours of the objects painted are delicately sketched with coloured pencils; these are peculiarly suitable for portraits. To this kind of drawings belong likewise those made with lead and silver pencils, upon paper and parchment, which are suitable for the delicate delineation of small objects. In some cases, drawings of this description are softly touched with dry colours. There is another style of drawing, in which Indian ink, or sepia and bistre intermingled with carmine and indigo, are used. The lights are produced by leaving the white surface uncovered. This mode produces the finest effect, and is very much used in the representation of all kinds of subjects.

There are various classes of drawings, as sketches, studies, academy figures, cartoons, &c. *Sketches* are the first ideas of the subject of a picture, thrown off hastily, to serve as the basis of a future drawing. They are made with charcoal, with the pen, or the pencil. To the rapidity of their execution may be ascribed the animation perceptible in the sketches of great masters, of which there are rich collections. *Studies* are copies of single parts of subjects, made either after life or from models; as heads, hands, feet, sometimes also whole figures. Drawings from skeletons and anatomical preparations, those of drapery, animals, plants, flowers, scenery, &c., are also called by this name. *Academy figures* are drawn from living models, who stand in academies of fine arts and other establishments, intended for the education of artists. The models, male and female, of all ages, are placed in different situations and attitudes, on an elevated spot, by lamp-light. The pupils stand round and draw, under the direction of professors. Experienced painters and sculptors likewise continue to draw from living models, either in private or in company. The most perfect figures, of course, are selected. In order to study drapery, a figure of wood, with moveable limbs, is placed so that the student can draw from it.

Cartoons are drawings on gray paper, of the same size as the paintings which are to be copied from them. These are, for instance, large oil paintings, fresco pictures, &c. Artists make use, also, of other means, in order to transfer the outlines of a painting upon another canvass, if they wish to copy very faithfully. If the copy is to be on a larger or a smaller scale than the original, it is customary to place on each canvass frames of wood, the space enclosed by which is divided, by means of threads, into quadrangular compartments. The compartments on the original are larger or smaller than the others, as the case may be. The artist then draws in each square of his canvass what he finds in the corresponding square in the original. If the copy is intended to be precisely of the same size with the original, the outlines are often traced through a black gauze, from which they are afterwards transferred by pressure to the canvass of the copy. This, it is true, does not give any distinct forms, but it indicates precisely the spot where every object is to be placed, which saves much time.

If the intention is to copy the outlines of the original exactly, it is necessary to make a *calque*, that is, a paper saturated with varnish, and quite transparent, which is put on the painting; the outlines are drawn; then the paper is blackened with crayon on one side, put on the new canvass, and the outlines are followed by some pointed instrument, and thus transferred to the canvass. It is evident that it is never allowable to take a copy in this way from very valuable pictures. The sketches of great masters are always valued very highly, because they show most distinctly the fire and boldness of their first conceptions. But for this very reason, because their excellence depends on the freedom with which they are thrown off, it is far more difficult to make copies from them than from finished paintings. The great schools in painting differ quite as much in respect to drawing as in respect to colouring. The style of drawing of the old Italian school is as hard, dry, and meagre as that of the old German school. The defects of the former are more often redeemed by beautiful forms and just proportions, whilst in the latter a meaning is frequently expressed which inclines more to poetry than to art.

At a later period, the Roman school became, in Italy, through the influence of Raphael's exquisite sense of the beautiful and expressive in form, and through the study of the antique, the true model of beautiful drawing. The Florentine school strove to excel the Roman in this respect, and lost, by exaggeration, the superiority which it might, perhaps, otherwise have gained from its anatomical correctness, and deep study of the art. The masters of the Florentine school often foreshorten too boldly. In the Lombard school, delicate drawing appears through enchanting colouring; but perhaps it is more true to nature and feeling than to scientific rules. The Venitian school, in reference to the other schools of Italy, has many points of resemblance, good and bad, with the Dutch school, in reference to Germany.

In the Venetian school, the drawing is often lost in the glow and power of the colouring; and it is very often not the nobleness of the figures and ideas in the drawing, but the richness, boldness, and glowing nature of the painting, which delight us. The French school was, in Poussin's time, very correct in drawing; and he was justly called the *French Raphael.*—At a later period, the style of this school became *maniéré*. David introduced again a purer taste in drawing, and a deep study of the antique. This study of the antique, together with the precision of their drawing, are the distinguished characteristics of the modern French school.

In Germany, there cannot be said to be any general style of drawing peculiar to her artists. The many distinguished artists of that country have formed themselves individually, by the study of nature and works of art; and whilst some of the most celebrated painters are distinguished for correct drawing, others are reproached for want of it, in some of their finest pictures. On the whole, their drawing is not so correct as that of the French. Many young German artists unfortunately consider the *naïveté* of the ancient masters of their country as beauty, and strive to imitate it.

Having thus furnished our readers with a brief view of the mechanical processes in drawing, and an outline of the peculiar features of the principal schools; it will be proper to examine the progress of design, commencing with simple lines. This is a subject that was admirably treated by Mr. Reinagle, in his Lectures, delivered in the Royal and London Institutions.

Fuseli thus describes the peculiar features of this important branch of the fine arts:—" Of design, the

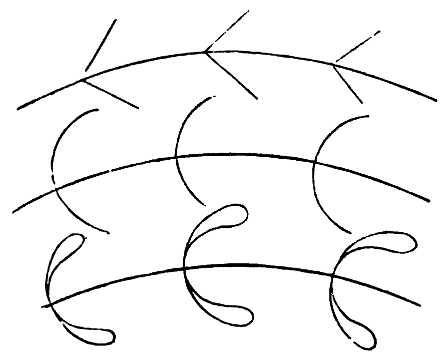
element is correctness and style; its extinction, incorrectness and manner. On the first principle of correctness, or the powér of copying and drawing with precision the proportions of any object singly, or in relation with others—as it may be considered in the light of an elementary qualification, without which none should presume to enter himself a student of the academy—I should perhaps forbear to speak, did I not consider it as the basis of design, and were I not apprehensive that from the prevalent bend of the reigning taste, you do not lay on it all the stress you ought; and that, if you neglect the acquisition of the power to *copy* with purity and precision any given object, you will never acquire that of *imitating* what you have chosen for your model. Our language generally confounds—or rather those who use it, when they speak of the art—the two words *copy* and *imitation*, though essentially different in their operation, as well as their meaning. An eye geometrically just, with a hand implicitly obedient, is the requisite of the former, without all choice, without selection, amendment, or omission; whilst choice, directed by judgment and taste, constitutes the essence of imitation, and raises the humble copyist to the noble rank of an artist. Those who have stopped short at the acquisition of the former faculty, have made a means their end, have debased the designer to the servile though useful draughtsman of natural history: and those who have aspired to the second, without gaining the first, have substituted air for substance, and attempted to raise a splendid fabric on a quicksand: the first have retarded the progress of the art; the second have perverted its nature: each have erred, to prove that the coalition of both is indispensable."

Every thing deserving the title of beautiful, and every grand object, assume an outline of definite character; the former in undulating lines of elliptic curves, and grandeur in angular dispositions of figure. Lines of motion, on the contrary, assume a curved direction. The first means of combining straight lines so as to please the eye, without creating any geometrical figure, is the radiating principle. Our eye not only can tolerate that union of lines, but receives the impression as pleasing in character; while all lines parallel to each other, being right lines, and viewed as a flight of steps, or pile of rods producing an opposite effect on the observer, are disagreeable.

Upon the former principle it is, that the rays of the sun, and rays of light generally, are so attractive and beautiful. It is from this circumstance that right lines, drawn in an inclined position to the plane of a picture, derive an interest from the angles engendered through the imagination. To follow up the principle by regular steps, and to open a clear view of the laws of beauty in lines, we may trace an inclined right line, with a regular set of right angles upon it, like the stems of leaves on each side. This exhibits no sort of beauty, nor any other advantage than mere combinations of formal angles. We may then draw an inclined line, as before, with similar angular projecting stems, to which should be added elliptic curves on the upper side of each branch, and the form of a leaf is produced. The next step is an incl ned line, having oval curves upon it. Both these possess principles approaching to beauty, by progressive advances in combination and original structure. An inclined line, with the oval curves upon it; to which are added elliptic curves on the upper side of each stem. This addition is a new advance towards beauty. A more perfect principle of beauty, having an elliptic stem with oval branches rising from it, will readily be conceived by the student.

If to this, the principle of gradation be given, by a scale of increase from the top to the bottom of the projecting stems; and if there be superadded the external contour of a lengthened egg, like the form of a sage-leaf, we shall, step by step, advance into the region of beautiful character in exterior design.

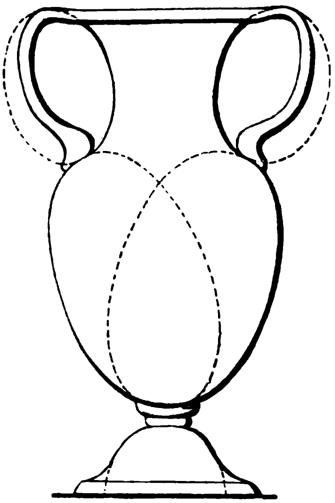
In the subjoined engraving we give three forms; in the latter is seen the elliptic stem with the oval branches rising from it, to which small serpentine additions are made, expressing a leaf.



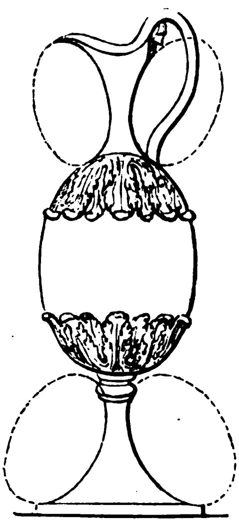
Of all the three diagrams to which we have adverted, the last abounds with the greatest portion of beautiful lines, and is indisputably the most agreeable and beautiful. Combinations are like numericals: many of these forms, placed together with judgment and discretion, will attract us from the larger proportion of beauty that meets the eye at once, like a head of beautiful hair: one hair, however gracefully bent, cannot impress us like an entire lock of the hair; nor will this curl charm us as the whole will on the human head. We owe to construction and combination all our pleasurable feelings of beauty: no person is allured by a single species of objects: but a thousand, or a million, arouses our anxious notice. Thus, the last diagram of the elliptic stem, and foliage upon it, exhibits, by the continuity of curved lines, the greatest approach to beauty, of any of its predecessors. These preliminary designs open the way for richer combinations. Curved lines of various quantities of convex and concave, drawn at random, without expressing or forming any sort of figure, please our eye more than any set of right lines similarly distributed. Quantity and variety are absolutely necessary to the production of perfect beauty; equalities being unfriendly to that symmetry which accords with nature. The combinations of the oval may be varied to an extraordinary extent. The vases represented in the engravings, though very dissimilar in appearance, are both the result of these combinations.

Here it may be proper to state, for the benefit of the student, that the most perfect collection of vases in this country are now deposited in the British Museum. They are placed in a room by themselves, and are of the greatest use to the artist. While upon this subject, we would remark, that as a general principle, too little attention is given by our young students to that splendid depository, as it is perfectly accessible to all.

The first, resembling a Greek vase with handles, is composed of seven parts. The body has four parts; the foot, or pedestal, one; the neck two. The handles are regulated in the position and projection by lines drawn from the bottom of the vase, through the ovals which compose the outline of the two sides, and passing through the transverse diameter. These handles are made from an oval that is the length of half the line of the transverse diameter. The skeleton of angles that govern the shape of this vase, is a very pretty figure of itself. The form does not proceed from any caprice or irregularity, but is consistent with rational organization, and symmetrical proportions. The other vase, represented beneath, exhibits an Hebe cup, with a handle which presents a totally different appearance in form to the previous one.



It is proportioned by similar principles: the large disc makes the body, inclining right and left upon the end of the oval. The neck and leg are both made from the smaller oval disc; the dotted lines to the ovals of the leg, sufficiently show the fact. The handle and concave lip of the cup, are made by an application of the same disc. The altitude contains four parts, the body two parts, the leg one part, and the neck one other part; the handle rises one-eighth above. Every portion of this figure is created by the two discs previously named. The foliage rises from below and descends from above, one-fourth of the whole height of the body to the commencement of the concavity of the neck, where the beading runs round. It has been remarked, that by adhering to regular proportional quantities of 1 and 2, 3 and 5, 2 and 5, 7 and 2, &c., and using elliptic discs or curves, very great beauties are derived.



The motion of ships at sea is described in gentle elliptic curves; the wings and plumage of birds assume the oval and elliptic curves; all the fibres of their feathers have that form; some flattened, others more rounded: the pine-apple and numberless fruits have all an oval character of outline. Many take the character of eggs, pointed at one end, and large and blunt at the other extremity. The leaves of trees have the oval shape more than any other; the bend of the branches, and the whole external form of many trees is oval. There is no form of created things which may not be found to correspond in all its dependant shapes, to ovals and ellipses of various discs; even objects which at first sight seem to contradict the possibility of meeting this system.

The Greek artists so confined themselves to certain rules and principles of unerring consequences, in the production of beauty, grace, or grandeur in their figures, that all their compositions depended upon the same species of rule and order. It is much to be regretted that fashion is in all countries the destroyer of taste; that it unfits the mind for fixed principles; that where it dominates, *there* taste will be always fluttering and never settle, nor have a sure dominion. The Greeks do not appear to have suffered themselves to be diverted from a pure course of design in their studies, and, as such, arrived at a very high degree of perfection in most scientific pursuits, by following sure principles as their guides, and by never abandoning a path traced by nature, and matured by the most sublime philosophy.

Pursuing our path in the subject of design, we at once come to the human form. The whole of our readers have, no doubt, seen, in the elementary treatises on drawing, the series of curves which form the human structure; to illustrate this, however, in the readiest way, we may turn to that great master of design, Raphael.

In this beautiful group, representing the Holy Family, the principle of the circle advancing to an oval is beautifully portrayed. In childhood, the circle predominates, but at a later period of life the face is elongated, and now though much of the prettiness begins to pass away, it is succeeded by the markings of a higher degree of intellect. The deeper and more powerful workings of the mind succeed to the infantile simplicity which marked the first dawning of reason.

In the beautiful curves which composed the vases first noticed, the forms must of necessity be the same under all circumstances; hence it will be obvious that the difficulty increases very considerably when we come to the varying characters, ages, and passions of mankind. The mode of delineating the human form, will, however, be discussed and illustrated under PORTRAITURE.

There is more of skilful design essential to a right arrangement of the folds in the drapery of a figure than the young artist is apt to imagine. The ancients excelled in *picturesque*, but not in *natural* drapery.—An example of the latter will be found in the figure beneath, designed by Flaxman.

We have heard of sculptors who design their drapery by laying layers of wet and flexible clay over the figure they are about to execute, but by such a process as that, little of real excellence could be produced. The ancient masters appear to have arranged their draperies as the upholsterer nails his curtain, in faultless form, and perfect order—nothing was left to chance. Now, to give a piece of drapery the slightest claim to a natural character, its whole arrangement must be that of chance; and no person can examine the simply natural masses, shown in the above figure, without at once observing the vast inferiority of the ancients under this head.

We must not, however, forget that this simplicity may easily degenerate into vulgarity, and poverty of conception. We may take as an example, the exquisite piece of drapery introduced by Chantrey, in his bust of the late Sir W. Scott. Now this has been copied by other inferior artists, and they have attempted, by the aid of a small handkerchief, or towel, to give the massive folds and beautiful contour of the original, and the consequence has been failure of the worst kind. Great depth of finish is not essential to good drapery—but just conception, and an acquaintance with the mechanical character of different fabrics.

In proof of what we have now been advancing, we may take one of the most beautiful groups probably in existence, and to which our artist has done ample justice. Cupid and Psyche possess in a peculiar degree, all the graces of the antique school. It has in this respect also its peculiar faults.

The waist of the male figure is encircled by a double row of drapery, forming unbroken lines of small plaits — now this is neither natural, nor yet picturesque. The drapery of Pscyhe much resembles that of the Caryatides, and is as quaint as it is unnecessarily indelicate. Flaxman and Canova, among modern sculptors, and Retsch and Frank Howard, in the pictorial art, stand highest in the power of embodying what is beautiful in the ancient school with the more natural character of real life. The dramatic illustrations of the latter form a distinct era in art. (See GROUPING and PORTRAITURE.)

DRAWING A PATTERN, in *weaving*, expresses the preparation of the figures with which the workman enriches his stuff, or silk, and which he copies after some painter, or eminent draughtsman; as in diaper, damask, and other flowered silk and tapestry, and the like. We are now enabled to manufacture pattern goods in this country, fully equal to, if not superior to the foreign artizans. In undertaking such kinds of figured stuffs, it is necessary, before the first stroke of the shuttle, that the whole design be represented on the threads of the warp; we do not mean in colours, but with an infinite number of little packthreads, which, being disposed so as to raise the threads of the warp, let the workman see, from time to time, what kind of silk is to be put in the eye of the shuttle, for woof. This method of preparing the woof is called reading the design, and reading the figure, which is performed in the following manner: A paper is provided considerably wider than the stuff, and of a length proportionate to what is intended to be represented thereon. This they divide lengthwise, by as many black lines as there are intended threads in the warp; and cross these lines, by others drawn breadthwise, which, with the former, make little equal squares: on the paper thus squared, the draughtsman designs his figures, and heightens them with colours, as he sees fit. When the design is finished, a workman reads it, while another lays it on the simblot.

To read the design, is to tell the person who manages the loom, the number of squares or threads comprised in the space he is reading; intimating, at the same time, whether it is ground or figure. To put what is read on the simblot, is to fasten little strings to the several packthreads, which are to raise the threads named; and thus they continue to do till the whole design is read.

Every piece being composed of several repetitions of the same design, when the whole design is drawn, the drawer, to re-begin the design afresh, has nothing to do but to raise the little strings, with slip-knots, to the top of the simblot, which he had let down to the bottom; this he is to repeat as often as is necessary till the whole be manufactured.

The ribbon weavers have likewise a design, but far more simple than that now described. It is drawn on paper with lines and squares, representing the threads of the warp and woof. But, instead of lines, whereof the figures of the former consist, these are constituted of points only, or dots, placed in certain of the little squares, formed by the intersection of the lines. These points make the threads of the warp that are to be raised, and the spaces left blank denote the threads that are to keep their situation: the rest is managed as in the former.

Dropsy; a preternatural collection of serous or watery fluid in the cellular substance, or different cavities of the body. It receives different appellations, according to the particular situation of the fluid.—When it is diffused through the cellular membrane, either generally, or partially, it is called *anasarca;* when it is deposited in the cavity of the cranium, it is called ***hydrocephalus;*** when in the chest, *hydrothorax*, or *hydrops pectoris;* when in the abdomen, *ascites;* in the uterus, *hydrometra;* and within the scrotum, *hydrocele.*

The causes of these diseases are a family disposition thereto, frequent salivations, excessive and long continued evacuations, a free use of spirituous liquors (which never fail to destroy the digestive powers), scirrhosities of the liver, spleen, pancreas, mesentery, and other abdominal viscera; preceding diseases, as the jaundice, diarrhœa, dysentery, phthisis, asthma, gout, intermittents of long duration, scarlet fever, and some of the *exanthemata;* a suppression of the accustomed evacuations, the sudden striking in of eruptive humours, ossification of the valves of the heart, polypi in the right ventricle, aneurism in the arteries, tumours making a considerable pressure on the neighbouring parts, permanent obstruction in the lungs, rupture of the thoracic duct, exposure for a length of time to a moist atmosphere, laxity of the exhalants, defect in the absorbents, topical weakness, and general debility.

The first of these species which we shall describe is *ascites* (from a sack or bottle; so called from its bottle-like protuberancy), or dropsy of the belly, a tense, but scarcely elastic, swelling of the abdomen from accumulation of water. Ascites is often preceded by loss of appetite, sluggishness, dryness of the skin, oppression at the chest, cough, diminution of the natural discharge of urine, and costiveness. After the swelling has commenced, it increases until the whole belly becomes uniformly swelled and tense. The distension and sense of weight vary somewhat with the position of the body, being greatest on the side on which the patient lies. As the collection of water becomes more considerable, the difficulty of breathing is much increased, the countenance exhibits a pale and bloated appearance, an immoderate thirst comes on, the skin is dry and parched, and the urine is very scanty, thick, and high-coloured, and deposits a lacteritious sediment. The pulse is variable, being sometimes considerably quicker, sometimes slower than is natural. The operation of tapping should be performed only where the distension is very great, and the respiration or other important functions impeded; and it will often be best not to draw off the whole fluid at once. Great care must be taken, also, to keep up a sufficient pressure, by a broad bandage over the abdomen, as even fatal syncope has arisen from neglect of this. The contraction of the muscles will be promoted by friction. The remedies for this disease are cathartics, diuretics, gentle friction of the abdomen with oil, &c. Tonic medicines, a nutritious diet, and, if the complaint appears giving way, such exercise as the patient can take without fatigue, with other means of improving the general health, ought not to be neglected.

Another species of dropsy, is called *anasarca.* It is occasioned by a serous humour, spread between the skin and flesh, or rather by a general accumulation of lymph in the cellular system.

This species of dropsy shows itself at first by a swelling of the feet and ankles towards the evening, which, for a time, disappears again in the morning. The tumefaction is soft, and inelastic, and, when pressed upon by the finger, retains its mark for some time, the skin becoming much paler than usual. By degrees, the swelling ascends, and occupies the trunk of the body; and, at last, even the face and eyelids appear full and bloated: the breathing then becomes difficult, the urine is small in quantity, high-coloured, and deposits a reddish sediment; the belly is costive, the perspiration much obstructed, the countenance yellow, and a considerable degree of thirst, with emaciation of the whole body, prevails. To these symptoms, succeed torpor, heaviness, a troublesome cough, and a slow fever. In some cases, the water oozes out through the pores of the cuticle; in others, being too gross to pass through them, it raises the cuticle in small blisters; and sometimes the skin, not allowing the water to escape through it, is compressed and hardened, and is, at the same time, so much distended, as to give the tumour a considerable degree of firmness. In some few cases, the disease goes off by a spontaneous crisis, by vomiting, purging, &c. Where the quantity of fluid collected is such as to disturb the more important functions, the best mode of relieving the patient, is to make a few small incisions with a lancet, not too near each other, through the integuments on the fore and upper part of each thigh; the discharge may be assisted by pressure.

In the use of issues or blisters, there is some risk of inducing gangrene, especially if applied to the legs; and the same has happened from scarifications with the cupping iustrument. Absorption may be promoted by friction, and bandaging the parts, which will, at the same time, obviate farther effusion; but most powerfully by the use of different evacuating remedies, especially those which occasion a sudden considerable discharge of fluids. Emetics have been often employed with advantage; but it is necessary to guard against weakening the stomach by the frequent repetition of those which produce much nausea.—Cathartics are of much greater and more general utility. Diuretics are universally proper. Digitalis is often a very powerful remedy. Opium, and some other narcotics, have been occasionally useful. In the use of diuretics, the patient should not be restricted from drinking freely. It is very desirable to promote evacuation by the skin. Sometimes much relief is obtained by promoting perspiration, locally,

by means of the vapour bath. Mercury has been much employed.

Regular exercise, such as the patient can bear (the limbs being properly supported, especially by a well-contrived laced stocking), ought to be enjoined, or diligent friction of the skin, particularly of the affected parts, employed when the tumefaction is usually least, namely, in the morning. The cold bath, duly regulated, may also, when the patient is convalescent, materially contribute to obviate a relapse.—The next species of dropsy which we shall consider is *hydrocephalus, hydrocephalom, hydrencephalus;* dropsy of the brain, dropsy of the head. It is sometimes of a chronic nature, when the water has been known to increase to an enormous quantity, effecting a separation of the bones of the head, and an absorption of the brain. Pain in the head, particularly across the brow, stupor, dilatation of the pupils, nausea, vomiting, preternatural slowness of the pulse, and convulsions, are symptoms of this disease. Hydrocephalus is almost peculiar to children, being rarely known to extend beyond the age of twelve or fourteen; and it seems more frequently to arise in those of a scorfulous and ricketty habit than in others. It is an affection which has been observed to pervade families, affecting all or the greater part of the children at a certain period of their life; which seems to show that, in many cases, it depends more on the general habit, than on any local affection, or accidental cause. The disease has generally been supposed to arise in consequence either of injuries done to the brain itself, by blows, falls, &c., from scirrhous tumours or excrescences within the skull, from original laxity, or weakness in the brain, or from general debility and an impoverished state of the blood.

With respect to its proximate cause, very opposite opinions are still entertained by medical writers, which, in conjunction with the equivocal nature of its symptoms, prove a source of considerable embarrassment to the young practitioner. When recoveries have taken place in hydrocephalus, we ought, probably, to attribute more to the efforts of nature than to the interference of art. It is always to be regarded as of difficult cure. The treatment should be prompt and active. The inflammatory action should be lessened, and then absorption promoted. After taking some blood by bleeding or by leeches, the torpid bowels are to be evacuated by some active cathartic, and their activity kept up, in the progress of the complaint, by calomel, or some other mercurial preparation. Mercury also contributes powerfully to rouse the absorbents.

After the bowels are cleared, some evaporating lotion is to be applied to the shaved scalp, and the antiphlogistic regimen observed. Sudorific medicines will generally be proper, assisted by the warm bath. Blisters may be applied to the temples, behind the ears, or to the nape of the neck. If the progress of the disease is arrested, the strength is to be established by a nutritious diet and tonic medicines.

Drosky; a kind of light, four-wheeled carriage, used by the Russians. It is not covered, and its side seats contain a greater or less number of persons. The lower wheels are covered with wings, which keep off the mud.

Drosometer; an instrument for ascertaining the quantity of dew which falls. It consists of a balance, one end of which is furnished with a plate fitted to receive the dew, the other containing a weight protected from it.

Drowning may be defined as death caused by immersing the exterior opening of the respiratory tube in a liquid. Actual death is often preceded by apparent death (*asphyxia*); and it is possible, if this state has not continued too long, to resuscitate a person apparently drowned. This circumstance has led to careful investigations of the nature of drowning, and also, in the neighbourhood of seas and large rivers, to the erection of public institutions for the resuscitation of persons apparently drowned. This kind of death furnishes, likewise, a difficult subject for medical jurisprudence, and gives occasion to the inquiry, whether a body found in the water was actually drowned, or whether life was lost in some other way; and great attention has been paid to the marks of this sort of death, which are to be found upon the body. But, notwithstanding all this pains, much uncertainty still hangs over the subject. This remark is true, as well of the manner in which death is the consequence of immersion, as of the signs of having been drowned, and the means of resuscitating from apparent death.

If a person voluntarily immerses his head in water, he perceives a roaring in his ears, a tickling in his nose, a pressure upon his breast, and a kind of stupid feeling. If a man, unable to swim, falls into the water, he instinctively makes every exertion to escape from it; he holds his breath, moves his head up and backwards, lays hold of every solid body which presents itself, and even grapples at the bottom of the water. These struggles continue a longer or a shorter time, according to the strength and presence of mind of the unhappy subject: at last, he sinks, exhausted, becomes unconscious, strives to breathe, draws in water, and life is gone. When the body is taken from the water, it is commonly found to be very cold; the limbs are stiff, the countenance distorted, livid, and often pale, the eyes half open, the pupils enlarged, the mouth filled with foam, the breast and region of the upper stomach expanded. Sometimes the body is still warm, though it cannot be reanimated, the countenance blue and distorted, the veins of the neck much swollen. This takes place when a person is drowned in alcohol, or in marshy or warm water, or when in a state of intoxication, or with a full stomach, or a heated body, a person falls overboard. On opening the body of a person who has been drowned, the epiglottis is found to be raised, bloody foam appears in the windpipe and bronchial passages, the lungs are soft and distended, a large quantity of black fluid blood is collected in the right, and less in the left cavity of the heart, a little water is in the stomach, and the vessels of the brain are swelled with blood. Death is sometimes caused by suffocation and want of air, and sometimes as in apoplexy: in the latter case, it happens very speedily, and a little water is sufficient to produce it, if the person falls upon his face. In this case, when the body is opened, the foam in the windpipe is wanting, and the vessels of the head are fuller. The various constituents of the water, such as irrespirable gases, contribute also to modify and complicate the mode of death.

The following are the methods of treatment recommended by the Humane Society for the recovery of persons in a state of suspended animation. As drowning is, probably, the most frequent accident by which animation is suspended, we give all the rules

of the society here, and shall refer them from FREEZING, HANGING, &c. to this article.

One of the first rules of the society is, that if a person be taken from the water, apparently drowned, send quickly for medical assistance; but do not delay the following means:—Convey the body carefully, with the head and shoulders supported in a raised position, to the nearest house. Strip the body, and rub it dry; then wrap it in hot blankets, and place it in a warm bed, in a warm chamber. Wipe and cleanse the mouth and nostrils. In order to restore the natural warmth of the body, move a heated covered warming-pan over the back and spine; put bladders or bottles of hot water, or heated bricks, to the pit of the stomach, the armpits, between the thighs, and to the soles of the feet; foment the body with hot moistened flannels; but, if possible, immerse the body in a warm bath, as hot as the hand can bear without pain, as this is preferable to the other means for restoring warmth; rub the body briskly with the hand; do not, however, suspend the use of the other means at the same time. In order to restore breathing, introduce the pipe of a common bellows (where the apparatus of the society is not at hand) into one nostril, carefully closing the other and the mouth; at the same time drawing downwards, and pushing gently backwards, the upper part of the windpipe, to allow a more free admission of air; blow the bellows gently, in order to inflate the lungs, till the breast be a little raised; the mouth and nostrils should then be set free, and a moderate pressure made with the hand upon the chest. Repeat this process till life appears. Electricity is to be employed early by a medical assistant. Inject into the stomach, by means of an elastic tube or syringe, half a pint of warm brandy and water, or wine and water. Apply sal volatile or hartshorn to the nostrils.

If apparently dead from intense cold, rub the body over with snow, ice, or cold water. Restore warmth by slow degrees; and after some time, if necessary, employ the means recommended for the drowned. In these accidents, it is highly dangerous to apply heat too early.—If apparently dead from hanging, in addition to the means recommended for the drowned, bleeding should early be employed by a medical assistant.

If apparently dead from noxious vapours, &c., remove the body into a cool, fresh air. Dash cold water on the neck, face, and breast, frequently. If the body be cold, apply warmth as recommended for the drowned. Use the means as above recommended for inflating the lungs. Let electricity (particularly in accidents from lightning) be early employed by a medical assistant.—If apparently dead from intoxication, lay the body on a bed with the head raised; remove the neckcloth, and loosen the clothes. Obtain instantly medical assistance, as the treatment must be regulated by the state of the patient; but, in the mean time, apply cloths soaked in cold water to the head, and bottles of hot water, or hot bricks, to the calves of the legs and to the feet.

If apparently dead from apoplexy, the patient should be placed in a cool air, and the clothes loosened, particularly about the neck and breast. Bleeding must be early employed by a medical assistant; the quantity regulated by the state of the pulse. Cloths soaked in water, spirits, or vinegar and water, should be applied to the head, which should be instantly shaved. All stimulants should be avoided.

In cases of *coup de soleil*, or strokes of the sun, the same means are to be used as in apoplexy. On restoration to life, a tea-spoonful of warm water should be given; and then, if the power of swallowing be retained, small quantities of warm wine, or weak brandy and water, warm; the patient should be kept in bed, and a disposition to sleep encouraged, except in cases of intoxication, apoplexy, and *coup de soleil*. Great care is requisite to maintain the restored vital action, and, at the same time, to prevent undue excitement. The treatment recommended by the society is to be persevered in for three or four hours. It is an erroneous opinion that persons are irrecoverable because life does not soon make its appearance; and it is absurd to suppose that a body must not be meddled with or removed without the permission of a coroner.

DRUM. Instruments which produce a sound by means of a tightly extended skin, are common in almost every part of the world. The tambourine is found amongst most nations; the ancients called it *tympanum*. All these instruments are used both for profane and sacred purposes. But the peculiar use of the drum for military purposes seems to have been introduced among the Europeans in the time of the Crusades. There are very many different kinds of drums in the East, described by Niebuhr.

The kettle drum, the bass drum, tambourine, and other kinds, are all common in the East. The drum, as a military instrument, is used both to beat the march and to give signals. No man, who has not experienced it, can imagine the exciting power of the drum. The fatigued and exhausted soldier is at once animated by its sound; and in battle it preserves order, and inspires courage in a body attacking *en colonne*. The French drummers perform admirably, and, under Napoleon, a great number were attached to each battalion. A drum which has acquired historical celebrity, is that which, by the order of Zisca, was covered with his own skin, that he might still aid in battle, where he had so often commanded, even after he had become blind.

DRUNKENNESS, considered in a *physical* point of view, is that derangement of the animal economy, which is produced by drinking spirituous or fermented liquors.

The effects of fermented liquor on the animal economy, arises principally from its *stimulating* power, or the power which it possesses of exciting the muscular parts to an increased rapidity and strength of action, as well as the nervous and mental qualities to an unusual degree of acuteness. When the animal functions are carried on with languor and feebleness, from whatever cause, the general sensations of the body are uneasiness, sometimes to a degree of pain. Thus, after long fasting, want of sleep, fatigue, or disease, this condition of the frame exists, and prompts us instinctively to the employment of some stimulus, as food, tepid, or fermented drink, the warm bath, &c. The immediate effect of such stimula, especially of fermented liquors, is the diffusion of a grateful sensation throughout the body; the languor and listlessness of the previous state are superseded by a general pleasurable feeling of warmth, energy, and self-command, accompanied by an indescribable tranquillity and complacency of mind; the countenance is enlivened with a glow of animation, in consequence of the free circulation through the cutaneous blood-vessels, and the renewed energy

occur in which entire deafness, taking place at the age of eighteen, so affected the articulation, that the individual was no longer intelligible, even to his friends. This result will not be prevented by any degree of hearing less than we have mentioned; for most deaf and dumb persons can hear some sounds; and some can distinguish the high from the low, who perceive no difference in articulations.

Only a few mutes are found who owe this defect to feebleness of mind, or to any imperfections in the organs of speech. These remarks show the fallacy of the idea, that the want of speech is owing to the want of mental capacity—a prejudice which has been cherished by the usual name of *deaf and dumb*, which we hope, for this reason, as well as for euphony, will be changed for that of *deaf mute*, which may be employed both as a noun and an adjective.

The number of deaf mutes varies materially in different countries, and situations, and classes of men. In the United States, partial examination leads to the belief that there is one deaf mute for every 2000 inhabitants. In some countries of Europe, there is one for every 1500 or 1700; in others, one for every 1000; and, in some locations, the proportion is three or four times as great as this. The proportion has been found greatest in some districts or portions of cities remarkable for the dampness and impurity of the air. The greater number of these unfortunate persons is found among the poorer classes; and hence it has been supposed, that the defect is frequently caused by the want of the necessary supplies and attentions during infancy or disease.

A large number of deaf mutes are born deaf; but it appears from the reports of a large asylum, that more than half the persons admitted lost their hearing by accidents or diseases, chiefly fevers and diseases of children.

The immediate causes of ordinary dumbness are known to be various. In some few cases, it is owing to an imperfection or injury of some part of the organs of speech, and, of course, is irremediable. In other cases, it seems to arise from obstructions in the external or internal passage of the ear. Cures have sometimes been effected by removing these obstructions by means of instruments or injections, especially, of late, by doctors Itard and Deleau, of Paris, who throw injections into the Eustachian passage, by means of a flexible tube passed through the nostrils. Doctor Deleau is reported, by a committee of the French Institute, to have relieved or cured several deaf persons, by injections of *air*, long continued; but he does not estimate the probable number of cures in deaf mutes at more than one in ten. Perforation of the tympanum is sometimes useful in rendering it more easy to remove obstructions which may be discovered; and, for this purpose, it is deemed important to perform it by means of circular discs, closing with a spring, which remove a portion of the membrane, and leave a permanent opening. In other cases, and in the usual mode, this operation often produces great suffering, and has not been generally useful.

In 81 cases of perforation at Groningen, in Holland, only three were permanently relieved, and these in a very partial degree. In the greater proportion of deaf mutes, no defect is visible, and no applications appear to be useful. In a number of anatomical examinations of deceased deaf mutes, at Paris, the ear was found perfect in all its parts. The inference has therefore been made, that the disease consists in a paralysis of the auditory nerve—a conclusion which seems to be sustained by the fact, that, in some cases, a cure has been effected by actual cautery on the back of the head, and that galvanism has sometimes given temporary relief. According to the estimates we have mentioned, the number of deaf mutes in the United States is about 6000, and in Europe not less than 140,000; all of whom, by their deafness (which we see is usually beyond the reach of remedies), are shut out from the intercourse of society, and the ordinary means of acquiring knowledge. The situation and character of such a large class of unfortunate persons are subjects of deep interest.

The necessity of communication, and the want of words, oblige the deaf mute to observe and imitate the actions and expressions which accompany various states of mind and of feeling, to indicate objects by their appearance and use, and persons by some peculiar mark, and to describe their actions by direct imitation. In this way, he and his friends are led to form a dialect of that universal language of attitude, gesture, and expression, by which the painter and the sculptor convey to us every event of history, and every feeling of the soul—which becomes a substitute for words in the hands of the pantomimic actor, and which adds force and clearness to the finest effusions of the orator—in other words, the natural *sign language*.

The terms of this language are of two kinds—the descriptive and the characteristic or indicative signs. Descriptive signs involve an account (more or less complete) of the appearance, qualities, and uses of an object, or the circumstances of an event, for the purpose of description or explanation, and must, from their nature, be varied, like a painting, only by the point of view from which the objects are described, or the capacity and accuracy of the person that describes. The indicative signs, on the contrary, which are employed in common conversation, are usually mere abbreviations of these, involving a single striking feature of the person, or object, or event; as an elephant is indicated by its trunk, a flower by its fragrance, or a town by a collection of roofs.

The signs of persons are usually conventional, and derived from some feature, or mark, or habit, but often from an accidental circumstance in dress, &c., which struck the deaf mute on first seeing the person, and is still referred to when it no longer exists. It is obvious that, in this class of signs, there is great room for dialects, according to the situation, capacity, and habits of observation of the individual, and that much may be done for its improvement, by a proper selection.

The sign language, like every other, varies in its extent with the intelligence, the wants, and the circle of ideas of those who use it. When employed by an insulated deaf mute, it will usually exhibit only the objects of the first necessity, and the most common impulses, like the language of a savage tribe. When his ideas expand, from age or observation, he will find new modes of expressing them; and, when his education is begun, an intelligent deaf mute will often express ideas in this language, for which it is difficult to find expressions in words. When a number of deaf mutes are brought together in a single institution, selections and combinations of their various dialects are formed; the best are gradually adopted by all; and a new and more complete form of the

language is the result—as in nations collected by civilization. This process, carried on for half a century in the institution of Paris, and some others in Europe, under the observation and direction of intelligent men possessed of hearing, has produced a language capable of expressing all the ideas we convey by articulate sounds, with clearness, though not always with equal brevity, and which those who value it least admit to surpass speech in the force with which it communicates the feelings and states of mind.

Like painting (as Condillac observes), it has the immense advantage of presenting a group of ideas at once, which lose much of their force and beauty, by being detailed in the successive words and artificial arrangements of written language. The eye, the hand, the whole body, speak simultaneously on one subject; the representation changes every moment, and these peculiarities, with the elliptical form of expression which is adopted in conversation, give a rapidity to communication by the sign language, which, on common subjects, among those familiar with it, surpasses that of speech. If we remark the new shades of meaning given to the same words, by the varying attitude and general expression of the speaker, and the accuracy with which a nice observer will discover, in these signs, the thoughts, and feelings and intentions, even of one who wishes to conceal them, we shall find reason to believe that they are capable of conveying the most delicate shades of thought.

Generic and abstract terms, as their objects do not exist in nature, have no corresponding terms of equal clearness in the sign language; and the abbreviated manner in which we express relations by conjunctions, prepositions, relatives, and inflections, can only be imitated by adopting similar conventional signs, which do not easily fall in with the idiom of the language. In these respects, therefore, the sign language wants the algebraic brevity and accuracy which are found in artificial languages, and which render these so invaluable as mediums of thought, and instruments of philosophical investigation; at the same time, it is capable of describing what is conveyed by these forms, with an accuracy at least as great as that of words, by circumlocution and example.

It is worthy of remark, that the order of expression, in the sign language, is that which we term *inverted*—the subject before the quality, the object before the action, and, generally, the thing modified before the modifier. This language, in its elements, is to be found among all nations, and has ever been the medium of communication between voyagers and the natives of newly-discovered countries. It is employed by many savage tribes to supply the paucity of expression in their language, or to communicate with other tribes, as in the Sandwich Islands, and in North America. Among the Indians of the western territory of the United States, Major Long found it an organised language, employed between tribes who spoke different articulate languages. The accounts received from himself, as well as his work, show that it corresponds, almost precisely, with that in use in the school of Paris; and a Sandwich Islander, who visited the American asylum for deaf mutes, gave a narrative of his life in the sign language, which was perfectly understood by the pupils. If testimony be wanting that it still retains its universal character, in its cultivated form, we may state that an intelligent writer, who acquired it in this form, observes that he has employed it, or seen it employed, with success, in communicating with an American Indian, a Sandwich Islander, a Chinese, and the deaf and dumb in England, Scotland, France, Germany, Switzerland, and Italy, and in various parts of the United States.

The more lively nations of Europe, belonging to the Celtic race, the French and Italians, &c. make great use of this language, in connection with words, and, sometimes, even without them. The more phlegmatic people of the Teutonic race, in England and Germany, are so little disposed to it, and so much less able to acquire or understand it, that they regard it as a species of affectation or buffoonery in their southern neighbours; and to this circumstance it is probaby owing, that it has been so extensively rejected, among these nations, as an auxiliary in the education of the deaf mute.

The natural condition of the deaf mute may be inferred from the account we have given of his language. It is obvious that the mere loss of hearing cannot, in itself, diminish the natural vigour of any other faculty, either of body or mind. He must, however, be destitute of all ideas of sounds; but these form so small a part of the circle of our ideas, in comparison with those derived from sight, that they cannot seriously affect him. His conceptions, derived through the medium of sight, are usually more accurate than ours, his recollections more vivid, and his powers of description more striking, because his attention is more undivided. His discrimination of feeling and character is often intuitive, and he frequently divines the subject of conversation from the appearance of the speaker. The tremendous part of his misfortune is the interruption of communication with his fellow-men, on all subjects except the primary wants and impulses, which arises from the imperfect character of his sign language, in an uneducated state. His ideas are very much limited to the objects and events he witnesses, and the exterior relations of things; and he is shut out from all the knowledge derived from history and tradition. Past ages, distant countries, a future world, a Deity, are all beyond his reach. In regard to the combination and application of the ideas which he acquires, he is still in the state of nations in the infancy of society, and cannot be aided or directed by others, in his efforts to reason.

After extensive observation and inquiry, we cannot hear of or find a single instance in which a person, born deaf, has conceived of a First Cause, from a view of the works of nature, without education. They describe themselves as looking at these objects like the brutes. Even those whose friends have made great efforts to communicate religious truths, seldom have an idea of the Deity, as a Creator or Benefactor; and a deaf mute at Chartres, in France, who had been taught to perform all the rites of the Catholic church, and was deemed very devout, on receiving his hearing, stated that he had no conception of any thing but the external forms of religion. Conscience, in them, derives all its light from the observation of the conduct of others, and the instinctive impulses; but recognises no invariable law, and often leaves these unfortunate persons to commit gross crimes, without any sense of guilt. In short, they are enveloped in intellectual and moral darkness, in the midst of the clearest light.

Mention is made of deaf mutes in the writings of

Pliny; and they were declared, by the Code of Justinian, incapable of civil acts. No attempts appear to have been made to give them instruction, until the latter part of the 15th century, when we are merely told by Agricola, professor of philosophy at Heidelberg, in Germany, of a deaf mute who had been instructed. In the middle of the 16th century, Pascha, a clergyman of Brandenburg, instructed a daughter, who was a deaf mute, by means of pictures. But the first effort for this interesting object, of which we have a distinct account, was made by Pedro de Ponce, a Benedictine monk, of the Spanish kingdom of Leon, who instructed four deaf mutes, of noble families, to write and speak, in 1570.

In 1620, John Bonet, another Spaniard, published the first book known on this subject, containing an account of the method which he adopted in a similar course of instruction, and accompanied by a manual alphabet, from which that now in use at Paris was derived.

In 1659, the instruction of deaf mutes was attempted, with apparent success, by Doctors Holder and Wallis, both of whom published accounts of their methods. At about the same time, Van Helmont, in Holland, published an ingenious treatise on the manner of forming articulate sounds, the principles of which, he says, he had applied with success to the instruction of a deaf mute. In 1691, John Conrad Amman, a Swiss physician in Leyden, published a similar work; but he and his predecessors appear to have devised and executed their plans without any knowledge of those who had previously attempted the same thing.

In 1704, the methods published in Spain, England, and Holland, were first applied, in Germany, by Kerger, apparently with much ingenuity and success, and some improvements. He was soon followed by a number of labourers in the same field, of whom Arnoldi appears to have been the most distinguished. In 1743, the practicability of instructing deaf mutes was first publicly demonstrated in France, by Pereira, a Spaniard, before the Academy of Sciences, who gave their testimony to its success. About the same time, this branch of instruction was attempted in France, by several others, among whom Deschamps, Ernaud, and Vanin were best known. In 1755, Heinicke in Germany, De l'Epée in France, both of whom were led to feel an interest in deaf mutes thrown accidentally in their way, formed each an independent system of instruction, established the first institutions for the education of deaf mutes, at Paris and Leipsic, and may be justly regarded as the founders of the two great schools, into which the instructors of the deaf mutes have since been divided. In 1764, Thos. Braidwood, of Edinburgh, devised a system of instruction, in which, as in that of Heinicke, articulation was the chief object. Both these persons, for a long time, refused to communicate their inventions, except for a compensation, and under the seal of secrecy; and their principles have scarcely extended beyond the countries in which they originated.

De l'Epée devoted his fortune and his life to the instruction of his pupils, and the gratuitous communication of the art to all who would learn it; and, in consequence of his efforts and instructions, schools were founded by Silvestri at Rome, Stork at Vienna, Guyot at Groningen, and Ulrich in Switzerland, which still exist in the hands of their disciples. The system of De l'Epée was materially improved by Sicard, his pupil and successor in the institution of Paris, who is admitted to have surpassed his master, and to rank with him as one of the greatest benefactors of the deaf mute. Towards the close of the last century, Assarotti, of Genoa, established, by his own benevolent efforts, an institution which ranks among the first in Europe, and formed a system of instruction, based, indeed, upon that in Sicard's works, but involving important improvements, which entitle him to be considered the founder of the Italian school.

The objects to be accomplished in the education of a deaf mute, are to teach him an entire language, and to give him all that mass of moral, religious, and ordinary knowledge that is necessary for him, as a social and immortal being, for which, in other children, 12 or 15 years of constant intercourse with society, and much study, are deemed necessary; all this is to be done in six, and often even in three years. It is obvious that, to accomplish this, some method, more rapid in its results than the ordinary one, must be adopted. The earlier instructors of the deaf mute usually had only one, or a very few pupils, and have given us *hints* for instruction, rather than a system.

The first account which we have of the reduction of this art to a regular and permanent form, is in the works of Heinicke and De l'Epée. Heinicke, like many of his predecessors, considered the want of speech as the great misfortune of the deaf mute, and made it the great object of instruction to teach him to articulate, in order to aid the progress of his own mind, as well as to enable him to communicate with others in this manner. We are told by the successor of Heinicke in the Liepsic school, that the following "are and were the views and principles of Heinicke and his disciples:"—that "we think in articulate words, and cannot think in written words;" "that written words can never lead to the development of ideas, in children born deaf;" and that "no freedom in thought, or in the use of language, can be produced without articulation, either by signs or by written language."

If it were credible that sounds were more allied to abstract ideas than objects of sight are; if we could forget that we often have ideas for which we cannot easily find words, the facts we have stated concerning the language of signs, and the capacity of several hundred pupils, educated merely by signs, in the English and American institutions, to read and write, and converse and reason, prove the entire fallacy of these views; and the argument *ab ignorantia* cannot be adduced, at this day, on that subject, without disgrace. Those who follow this system admit the use of the sign language in the early stages of instruction, but seek to banish it as early as possible, considering it as a rude language, incapable of improvement, and which retards the expansion of the pupil's mind, and renders it less necessary for him to attend to written language. They adopt the methods of the early instructors, in waiting for occasions to teach words and explain phrases. They rely upon repeating the word or phrase in the appropriate circumstances, and in questions and answers, as the means of making it understood, rather than on direct explanation, or examples presented by the sign language. Too many of this school forget one of the fundamental maxims of Heinicke—"first ideas, then words"—and occupy the pupil for a long time with mere mechanical articulation. In one school, months are passed in the mere study of names attached to

pictures, without the least attempt to excite or enlighten the mind by means of signs; and usually a year is passed, at a period of life when most of the mental faculties are ripe for development, in the mere exercise of memory (in learning names of objects, and qualities, and actions), which only requires the powers of an infant, and would be aided, instead of retarded, by the expansion of the mind, as the experience of the other schools fully proves.

Religious instruction is rarely attempted in this school before the second year, or until it can be given in words, from the belief that it cannot be given correctly by signs; and in the school of Leipsic, it is even deferred to the third year. The attention of De l'Epée, and other instructors of the same views, was called especially to the intellectual and moral wants of the deaf mute; and they deemed it most important first to develope his powers, and cultivate his feelings; and, next, to give him such a knowledge of written language as is indispensable to the acquisition of knowledge, and the communication of his wants. They found the only medium of conveying truth, or explaining terms, in the sign language which we have described; and thus having formed the basis of a permanent system, they employed it in its natural state, to explain the first simple terms. They discovered that it was capable of extension, and they preserved and cultivated it, as we have mentioned, as a language intelligible to the pupil, by which they could always refer to any objects of thought or feeling, physical, intellectual, or moral, and thus form original explanations of new words, and avoid the error which might arise from the imperfection of previous explanations. Words they considered as arbitrary signs, and De l'Epée maintained, that the instruction of the deaf mute, like that of a foreigner, ought to consist in a course of translation, and retranslation, from the known to the unknown language. To aid in this process, he added a series of methodical and conventional signs, founded on analogy, for the particles and inflections of language. These were used chiefly in instruction, in order to render the translation complete, as well as to indicate the character and meaning of the connectives. He does not appear to have practised fully upon his own principles, but occupied himself too exclusively with the intellectual improvement of his pupils, and with single words, and seems to have despaired of enabling them to use language, in its connection, except in a mechanical manner.

Sicard endeavoured to complete the plan of his master, by the improvement of the signs employed; and to him and his pupils we owe, more than to any others, the perfection which this language has attained. He also endeavoured to avoid the error of De l'Epée, by explaining the theory of grammar, and the formulas of the various species of propositions, and, in this way, was led into a course of metaphysical and philosophical lessons, which later instructors have found too extensive and too little practical.

According to the system adopted under his direction, the first year was occupied with a vocabulary of names, of adjectives, and of verbs in three simple tenses, with simple religious and other narratives in the sign language. It was only in the second year, that words were shown, in their connection, in short phrases; the pronouns, prepositions, and the full inflection of the verbs, were taught, and religious instruction given, in written language. In the third and fourth years, the organs, senses, and operations of the mind, and the theory of sentences, were explained, original description and definitions required, and in the fourth year books were put into the hands of the pupils. Throughout the course, public lectures were given, in which written accounts of Bible history, and religious truth, were explained in the sign language; but no devotional exercises in this language were ever connected with them, or practised by the pupils.

The American system has been materially modified in the school of Paris itself, and in several others on the continent of Europe, which adopt the same principles. As the American system of instruction, devised by Mr. Gallaudet, without any knowledge of others, except that of Paris, on which it is founded, comprises most of these improvements, with some others of great importance, peculiar to itself, we cannot do better, within the limits allowed us, than to describe this as we have found it, in his own statement, and in the American Asylum. Mr. Gallaudet has combined the fundamental principle of Heinicke —"first ideas, then words"—with that of De l'Epée —that "the natural language of signs must be elevated to as high a degree of excellence as possible, in order to serve as the medium for giving the ideas clearly, and explaining them accurately." He has added another of no small importance—that, as words describe rather the impression, or states of mind produced by external objects, than those essential qualities which are beyond our reach, the process of learning them would be facilitated by leading the pupils to reflect on their own sensations and ideas; and he states, as the result of his experience, that, among deaf mutes of equal capacities, "those who can be led to mark or describe, with the greatest precision, the operations of their own mind, uniformly make the most rapid progress in the acquisition of written language, and of religious truth." A leading object, therefore, in connection with the first lessons, in which sensible ideas are presented and named, is to establish a free communication with the pupil, in the sign language, in reference to his feelings and thoughts, as excited by the objects which he sees, or the events of his own life. He easily comprehends those of others, and is thus led to learn the names of the simple emotions and acts of the mind. Hence he is brought to think of an invisible agent, which we term the *soul*, as the feeling and percipient being; and, by a natural transition, is led, by the use of signs alone, to the Great Spirit, as the first cause; to his character, as our creator and benefactor; and to a knowledge of his law and our future destiny. In this manner, the deaf mutes in the American asylum (and, we presume, in others derived from it) are made acquainted with the simple truths of religion and morality in one year; a period in which, in most European institutions, they are scarcely advanced beyond the knowledge of the sounds, and the names of sensible objects, qualities, and actions, or the most common phrases.

By communicating this instruction in the natural sign language, pupils, whose inferior capacity or advanced age would not allow them to acquire enough of written language to receive religious truth through this medium, have been early prepared to enjoy its blessings and hopes, and feel its sanctions as a restraint upon their conduct, which renders their

government more easy, while it aids them in the formation or correct notions.

Another plan, which is not known to have been ever employed before its introduction by Mr. Gallaudet, in 1817, was to conduct the daily and weekly devotional exercises by signs; and the deaf mutes have been thus taught to address the Father of their spirits in their own natural language, and have been admitted to the new privilege of social worship.

In applying the first principles to the course of instruction in language, an important improvement has been made, by combining words into phrases as early as possible, and thus teaching the pupil how to use them. The idea of each phrase is first explained by the sign language, and then translated into words, and then retranslated by the pupil into his own language. The process is carried on for more difficult words, and the phrases are lengthened until they become narratives. The acquisition and use of the connectives are aided by the methodical signs of De l'Epée and Sicard. The pupil is called upon, at intervals, to express his own ideas in writing, and to explain by signs what is written by others. An important additional improvement is "to employ the pupil, as early as possible, in the study of books written in an easy style, explained by signs when necessary," so as to lead him, by his own and often by his unaided efforts, to become acquainted with the arrangemement of words, and the idioms of written language. He is led gradually to infer the rules of grammar from a series of examples, instead of committing them to memory; and the theory of language is reserved for the later years of instruction, when the pupil is familiar with its practical use.

The methods of instruction in the elements of arithmetic, geography, and history, do not differ materially from those usually employed, except that much aid is derived from explanatory signs; and experiments, made in some of the schools both in England and France, prove that those may be usefully employed to illustrate various subjects to persons possessed of hearing.

While the instructors of the school of De l'Epée and Sicard unite in denying that articulation is necessary to the deaf mute, as a means of mental development, they admit its great value as a supplement to intellectual education, if it be attainable. But they differ as to the practicability and expediency of attempting to teach it generally. Of its great practical value in darkness, or in cases of sudden danger, there can be but one opinion; and it is certainly important that every deaf mute should be taught some cry of distress, or perhaps a few words for such occasions; for some do not know how to use their voice even to this extent.

The power of articulating, even imperfectly, may also be of great importance to the deaf mute, where ignorance in writing is combined with a phlegmatic inattention to signs, in those among whom he is situated. But that it is not indispensable, as an ordinary means of communication, is proved by the fact, that the pupils of the French and American schools, find no difficulty in making themselves intelligible to those around them, either by writing or signs, on all necessary subjects.

Articulation is learned and recollected by the deaf mute, as a set of movements and sensations in the organs of speech. It is taught by pointing out to the pupil the powers of the vowels and consonants, and the position of the lips, teeth, and tongue, and by making him feel with his hand, or a silver instrument, all the perceptible movements and vibrations of the throat and interior organs, which are requisite for their pronunciation. He is then required to imitate this position, and to force a quantity of air from the lungs, sufficient to produce the sound, and is taught to read the articulations of others, by observing the position of the organs and the countenance. The facility of doing this, will depend much upon the pliability of the organ of speech, and the nature of the language to be learned. We observed, as would naturally be supposed, that the soft and regular language of Italy, in a climate where we have other evidence of a superior pliancy of the vocal powers, was acquired with tolerable success, by a short period of daily practice. But the harsh and gutteral sounds of the northern languages, and the irregularity which is found in the pronounciation of some of them, present several additional difficulties, which are perhaps increased by the frequent diseases of the vocal organs, produced by a cold climate. Those instructors who attempt to teach all their pupils these languages, are usualy compelled to make it a constant and individual exercise, and to make and to demand efforts painful to the teacher, and pupil, and spectator, with only a partial success. Of a number of speakers, whom we have seen and heard of, in various countries, thus taught, few would have been intelligible to a stranger so readily as by signs; and their tones were extremely disagreeable. On the other hand, we have seen a few deaf mutes who are capable of speaking in a manner perfectly intelligible, and of reading from the lips and countenance, what was said by others. They were such, however, as either retained some remnant of hearing, or had been the subjects of individual instructions for a series of years. We presume the truth lies in that middle course, now adopted by the school of Paris, and by some advocates of articulation, who have had an opportunity of observing it in all its forms. They believe that, by that portion of the pupils of every institution, whose organs are pliable, and who have some remnant of sensibility, either in the external or internal ear (those termed *demi sourds* in the Paris school), the acquisition may be made with a degree of ease and perfection, which renders it a desirable and important branch of instruction for such portion of the pupils, in every institution. They are equally convinced, that to attempt to teach articulation to those entirely destitute of sensibility in the ear, or who cannot exercise the organ of speech without difficulty or pain, is a useless labour, and may produce disease in the pupil; as more than one instance proves. On the last point, some have maintained that the exercise of the lungs is important to the pupil, while others have declared the contrary. We believe here, also, much will depend on individual organization, and that the general question will be modified much by the climate, and nature of the language to be taught. Most of the schools for deaf mutes employ a manual alphabet, for the more rapid communication in words: in this country usually made with both hands, and elsewhere with one. This alphabet, with writing, on paper and in the air, and the use of natural and conventional signs, are found adequate means of communication for those who cannot acquire articulate language.

DWARFS. In ages when knowledge depends mostly on tradition, it is natural for the human mind to people the world with a thousand imaginary beings. Such are dragons, giants, and dwarfs; all of which have some foundation in reality, and afford amusement to the imagination, even after experience has corrected the belief in the reality of their marvellous character. We need hardly say, that the pygmies of the ancients, and the Quimos, whom Commerson tells us that he discovered, are as fabulous as the renowned Lilliputians. The dwarfs which actually exist are deviations of nature from her general rule; and the term *dwarf* is a vague one, as we cannot say how small a person must be, to be so called. There is no instance on record of dwarfs distinguished for great talents. Their figures are sometimes perfectly well proportioned. They have generally one trait in common with children—a very high opinion of their own little person, and great vanity.

The Romans used dwarfs for several purposes; sometimes in gladiatorial exhibitions, on account of the ridiculous contrast which they afforded to their opponents. Towards the end of the middle ages, and even, in some countries, as late as the beginning of the last century, dwarfs were a fashionable appendage to the courts of European princes, and the families of the nobles. Who does not recollect the numerous pictures of those times, with a Negro or a dwarf in the back ground? They seem to have been great favourites with the ladies of the family. They were sometimes, also, used as jesters. Peter the Great carried this fancy for dwarfs to a great extent. He assembled individuals of this kind from all parts of his empire, and ordered the famous marriage of the dwarfs. At the court of Constantinople a number of dwarfs are always maintained, as pages. Those who happen to be, at the same time, deaf and dumb, and have been mutilated, are particularly valued, and reserved for the sultan.

DYEING is a chemical art, and consists in fixing upon cloths of various kinds any colour which may be desired, in such a manner as that they shall not easily undergo any alteration, by the agents to which the cloth is ordinarily exposed. The chief materials or stuffs to be dyed are wool, silk, cotton, and linen; of which the former two are more easily dyed than the latter.

Wool, in its preparation for dyeing, requires to be cleansed, by scouring, from a fatty substance, called the *yolk*, which is contained in the fleece. This is done by means of a weak alkaline solution, which converts the yolk into soap. Urine is commonly employed, on account of its cheapness; the ammonia it contains being sufficient to remove the grease.

Silk, when taken from the cocoon, is covered with a kind of varnish, which, because it does not easily yield either to water or alcohol, requires also the aid of a slight portion of alkali. Much care is necessary, however, in this operation, since the silk itself is liable to be corroded and discoloured. Fine soap is commonly used; but even this is said to be detrimental; and the white China silk, which is supposed to be prepared without soap, has a lustre superior to the European.

The preliminary process of washing is intended to render the stuff to be dyed as clear as possible, in order that the aqueous fluid, to be afterwards applied, may be imbibed, and its contents adhere to the minute internal surfaces.

Another preparation, and one which constitutes, in reality, an important part of the dyeing process, consists in applying to the stuff, a material to which it adheres; and afterwards the desired colour is obtained by the application of another substance. We might dye a piece of cotton black, by immersing it at once in ink; but the colour would be neither good nor durable, because the particles of precipitated matter are not sufficiently comminuted to enter the cotton, or to adhere to it firmly. But, if the cotton be soaked in an infusion of galls, then dried, and afterwards immersed in a solution of sulphate of iron, the acid of galls being everywhere diffused through the fabric, it will receive the particles of oxide of iron, at the very instant of their transition from the fluid to the solid state; by which means a perfect covering of the black, inky matter will be applied in close contact with the surface of the most minute fibres of the cotton.

The name of *mordant* is applied to those substances which unite with the different stuffs, and augment their affinity for the various colouring matters. There exists a great number of mordants; some, however, are very feeble in their activity, while others are attended with too much expense for common stuffs; some alter the colours which they are intended to combine, or modify their shades: hence it results, that there are but a small number which can be employed. These are alum, acetate of alumine, muriate of tin, nut-galls, &c.

The mordant is always dissolved in water, into which the stuffs to be dyed are plunged. If the mordant be universally applied, over the whole piece of goods, and this be afterwards immersed in the dye, it will receive a tinge over all its surface; but if it be applied only in parts, the dye will strike in those parts only. The former process constitutes the art of *dyeing*, properly so called; and the latter the art of printing cottons, or linens, called *calico-printing*.

In the art of printing piece goods, the mordant is usually mixed with gum or starch, and applied by means of blocks or wood engravings, in relief, or of copper plates, and the colours are brought out by immersion in vessels filled with suitable compositions. The latter fluids are termed *baths*. The following are the processes usually adopted, when alum is the mordant employed:

1. *Alum mordant for silk.* Into water containing the 60th part of its weight of alum, at the ordinary temperature of the air, the silk is plunged, and allowed to remain for 24 hours, when it is withdrawn, drained, and washed. If the liquid is warmed, it is found that the silk absorbs less of the mordant, and that, of course, it combines less easily with the colouring matter, besides losing, in part, its natural gloss.

2. *Alum mordant for wool.* When it is wished to combine wool with this mordant, after its cleansing has been effected, it is plunged into a boiling solution, composed of 8 or 900 parts of water, and 25 of alum, where it is allowed to remain during two hours; when it is taken out, suffered to drain, and washed.

Frequently a little cream of tartar is added in this process, in order to engage the excess of acid in the alum, as well as the portion arising from a slight decomposition of the alum by the oily matter of the wool.

3. *Alum mordant for cotton, hemp, and flax.* This operation is effected by plungnig the body to be

imbued with this mordant into water slightly warmed, and which contains one quarter of its weight of alum, and leaving it 24 hours, at the common temperature of the air; when it is withdrawn, washed, and dried. The cotton will be sufficiently imbued with the mordant, if allowed to remain in the solution only 7 or 8 minutes, pressing it a little, without twisting it, however, on taking it out, and not immersing it in the colouring bath until 12 or 15 hours after. In all alum mordants for wool, the alum of commerce may be employed; but when silk or cotton is to be dyed, especially if the colours are bright, it is necessary to make use of the alum of Rome, or of that which is equally pure; that is to say, of alum which does not contain above 1-500th of its weight of sulphate of iron; otherwise there will be a great quantity of oxide of iron adhering to the fabric, which will affect the shade we desire to obtain. The colouring matters to be transferred to the various stuffs are either soluble or insoluble in water. When they are soluble in water, which is most generally the case, they are dissolved in it at a boiling temperature; and the material to be dyed, after having been duly prepared, and impregnated with the mordant, is plunged into it, where it is allowed to remain for a certain time, and at a temperature varying with the nature of the stuff. When, on the contrary, the colouring matter is insoluble in water, its solution is effected in some other fluid, and the article to be coloured (prepared as in the former case, with the exception that the application of the mordant is omitted) is immersed, and the colouring matter is precipitated by the addition of a third body. Silks are dyed at a temperature which is gradually increased from 86° to 175° Fahr. If the bath is heated above 86°, at the commencement of the process, the effect of the mordant is diminished, and the desired shades of colour will not be produced. For the same reason, in dyeing hemp and flax, the temperature should not exceed 97° Fahr. Cotton and woollens may be dyed at a boiling heat.

Various mechanical contrivances are made use of in immersing the different materials to be dyed into the colouring solution, so as to cause all their parts to be equally affected at the same time. As soon as they are withdrawn from the colouring bath, they are washed in a large quantity of water, in order to deprive them of those particles of colouring matter that are merely superficial.

The following are the dye-stuffs used for producing *fast* colours: 1. *Black.* The cloth is impregnated with acetate of iron (iron liquor), and dyed in a bath of madder and logwood. 2. *Purple.* The preceding mordant, diluted, with the same dyeing bath. 3. *Crimson.* The mordant for purple, united with a portion of acetate of alumine, or red mordant, and the above bath, 4. *Red.* Acetate of alumine is the mordant, and madder is the dye-stuff. 5. *Pale red,* of different shades. The preceding mordant, diluted with water, and a weak madder bath. 6. *Brown of Pompadour.* A mixed mordant, containing a somewhat larger proportion of the red than of the black, and the dye of madder. 7. *Orange.* The red mordant, and a bath, first of madder, and then of quercitron. 8. *Yellow.* A strong red mordant, and the quercitron bath, whose temperature should be considerably under the boiling point of water. 9. *Blue.* Indigo, rendered soluble and greenish-yellow coloured, by potash and orpiment. It recovers its blue colour by exposure to air, and becomes firmly fixed upon the cloth.

An indigo vat is also made by diffusing indigo in water, with quicklime and copperas. These substances are supposed to act by deoxidizing indigo, and, at the same time, rendering it soluble. *Golden dye.* The cloth is immersed alternately in a solution of copperas and lime-water. The protoxide of iron, precipitated on the fibre, soon passes, by absorption of atmospherical oxygen, into the golden-coloured deutoxide. *Buff.* The preceding substances, in a more dilute state. *Blue vat,* in which white spots are left on a blue ground of cloth, is made by applying to these points a paste, composed of a solution of sulphate of copper and pipe-clay, and, after they are dried, immersing it, stretched on frames, for a definite number of minutes, in the yellowish-green vat, of one part of indigo, two of copperas, and two of lime, with water. *Green.* Cloth dried blue, and well washed, is imbued with the acetate of alumine, dried, and subjected to the quercitron bath. In most of the above cases, the cloth, after receiving the mordant paste, is dried, and put through a mixture of cow-dung and warm water. It is then put into the dyeing vat or copper. The foregoing colours are also produced from decoctions of the different colouring woods; but, as they possess but little fixity when thus formed, they are denominated the *fugitive* colours. 1. *Red* is made from Brazil wood and peach wood. 2. *Black.* A strong extract of galls and deuto-nitrate of iron. 3. *Purple.* Extract of Logwood and the deuto-nitrate of iron. 4. *Yellow.* Extract of quercitron bark, or French berries, and nitro-muriate of tin. 5. *Blue.* Prussian blue and solution of tin. Fugitive colours are thickened with gum tragacanth, and are sometimes sent to market with out being washed.

DYNAMETER, measurer of increase, *augomètre;* an instrument for measuring the magnifying power of telescopes. It consists of a small tube, with a transparent plate, exactly divided, which is fixed to the tube of a telescope, in order to measure exactly the diameter of the distinct image of the eye-glass.

DYNAMICS is the science of moving powers, or of the action of forces on solid bodies, when the result of that action is motion. *Mechanics,* in its most extensive meaning, is the science which treats of quantity, of extension, and of motion. Now, that branch of it which considers the state of solids at rest, such as their equilibrium, their weight, pressure, &c., is called *statics;* and that which treats of their motion, *dynamics.* So when fluids, instead of solids, are the subjects of investigation, that branch which treats of their equilibrium, pressure, &c., is called *hydrostatics,* and that which treats of their motion, *hydrodynamics.*

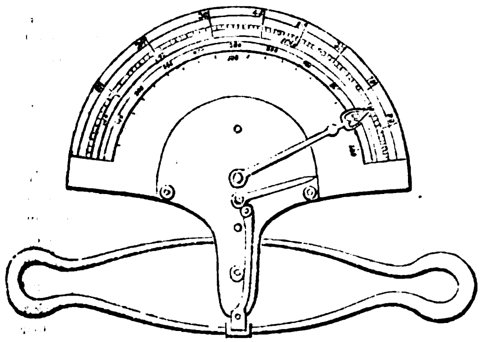
DYNANOMETER; an instrument for ascertaining the relative muscular strength of men and other animals. That it would be desirable to know our relative strengths at different periods of life, and in different states of health, will hardly be denied; and there can be no doubt but that it would be highly useful to have a portable instrument by which we could ascertain the strength of horses or oxen intended for the plough or the waggon. Such an instrument was invented many years ago, by Graham, and improved by Desaguliers; but, being constructed roughly of wood, it was too bulky to be portable, and therefore it was limited in its use.

M. Leroy constructed a much more convenient dynanometer than Graham's, consisting of a metal tube, ten or twelve inches in length, placed vertically

on a foot like that of a candlestick, and containing in the inside a spiral spring, having above it a graduated shank terminating in a globe. The shank, together with the spring, sunk into the tube in proportion to the weight acting upon it, and thus indicated, in degrees, the strength of the person who pressed on the ball with his hand.

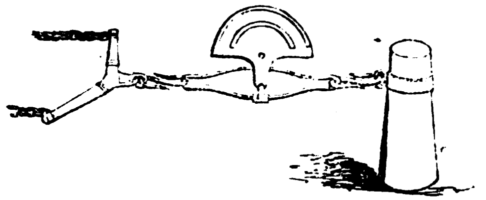
This was a very simple construction; but Buffon and Gueneau, being anxious to estimate the muscular force of each limb separately, and of all the parts of the body, they employed M. Regnier to contrive a new dynanometer; and the account which he gives of his attempts to fulfil their wishes, is calculated to enhance the difficulty of the attempt. The instrument, however, which he constructed is not of such a character as appears to have required any uncommon skill in mechanics, or any great stretch of thought. It consists chiefly of an elliptical spring, twelve inches in length, rather narrow, and covered with leather, that it may not hurt the fingers when compressed by the hands. This spring is composed of the best steel well welded and tempered, and afterwards subjected to a stronger effort than is likely to be ever applied to it either by men or animals, that it may not lose any of its elasticity by use.

The effects of this machine are easily explained. If a person compresses the spring with his hands, or draws it out lengthwise, by pulling the two extremities in contrary directions, the sides of the spring approach towards each other; and it has an apparatus appended to it, consisting of an index and a simicircular plate, by the degree of approach, and consequently of effort, employed, is ascertained with great accuracy. There is a very full account of this machine in the fourth number of the *Philosophical Magazine*.



In the above engraving we give a view of a very useful dynanometer, very similar to that already referred to. The divided arc is attached to the upper portion of the spring, and the index hand is put in motion directly the two plates approach each other, by the short perpendicular rod shown in the figure.

The engraving in the next column shows the apparatus as it is employed for measuring the strength of animals. A strong pillar is inserted in the ground, to which one end of the dynanometer is attached, and the horses or other animals hooked to the other: and it will be obvious that the efforts of the animal will be duly indicated by the hand traversing the arc. There is, however, a still more advantageous mode of employing it, which consists in attaching it to a loaded vehicle, and then the experimentalist has all the advantages which arise from employing the animal's strength in a natural way.



Dyscophosis; a defect in the sense of hearing.

Dyscracy; an undue mixture of elements in the blood or nervous juice.

Dysorexy, among physicians, denotes a want of appetite, proceeding from a diseased state of the stomach.

Dyspepsia; difficulty of digestion. The strict etymology of the term implies an imperfect or disordered condition of the function of digestion. Systematic writers have been not a little perplexed to find an appropriate location for this affection in their artificial arrangements; and this difficulty must exist whilst symptoms, which are always fluctuating, are admitted, as the elements of nomenclature and arrangement, into systems of nosology. From the same circumstance, different symptoms of the affection have received the character of separate diseases, as apepsia, bradypepsia (βραδυς, slow), anorexia, cardialgia, &c. These are no more than different grades in the symptoms, or varieties of the affection, and are not different diseases.

The disorder of the digestive function is the most frequent and prevailing of the ailments that afflict man in the civilized state; all classes and all ages suffer from its attacks. Few are so happy as to pass through a life of ordinary duration, without undergoing a protracted struggle with this malady, and experiencing its torments. Once let it be fully established, and the comfort of existence disappears, or is regained, in most cases, tediously, and at the price of the most ascetic self-denial.

The greater prevalence of dyspepsia or indigestion, in modern times, arises from the more frequent injury done to the stomach and its functions, directly, by the habits of luxurious indulgence, which have been exceedingly increased and extended; and, indirectly, by the multiplication of intellectual and moral agitations, from the extension of the commercial and financial operations of society, the greater activity and employment of the intellectual faculties, and augmentation of political, social, and individual reverses. Something, too, is to be ascribed to the mere change of names.

We call that *dyspepsia* now, which, formerly, was termed *liver disease, bilious disorder*, &c. A large proportion of the discomfort produced by this malady, arises from an ignorance of the digestive functions, leading to their abuse and premature derangement, and may be obviated, to a great extent, by instruction as to the nature of these functions, and their natural exercise. A general view of the digestive organs and functions is, therefore, requisite to an understanding of their disorders, the means to prevent, and the methods to remedy them.

All organized or animated beings hold their existence under the condition of renewing, incessantly,

the elements of their composition, by the appropriation to themselves of exterior matters. The simple animals (polypi, &c.) find, in the medium in which they live, and from which they directly receive them, the principles serving for their composition. The decomposition of animal and vegetable matter in the soil, prepares the aliment or nutritive principle of vegetables, which, being held in solution by water, is absorbed by their roots. In all these beings there are no digestive organs or functions. The preparation of their nutriment is effected by physical operations exterior to themselves, over which they have no controul. In the higher or complete animals, or in man, the case is very different. Nature does not present to them the nutritive elements in a state fitted to be introduced, at once, into the interior organization, and to be employed in its composition. Their aliment consists of the nutritive principles in a compound state, intimately combined with other substances, from which they require to be disengaged. This is accomplished by the animal itself, which is provided with especial organs, or apparatus and functions for this purpose.

Digestion, then, consists in the disengagement of the nutritive elements from their combinations, and their reduction to the molecular state, admitting their introduction into the vessels, and their diffusion throughout the organization, for the purposes of its composition. It is a process analogous to the decomposition of the aliment of vegetables in the soil, and is effected, like all decompositions, by analogous or chemical operations. In this class, the procuring of the aliment is the act of the animal, depending on its voluntary powers, and is controlled by a great variety of circumstances, affecting the quantity and quality of the food. The organs composing the digestive apparatus in man are numerous. They are the mouth, armed with teeth, for mechanically breaking down the food by mastication; the salivary glands, furnishing a fluid intimately combined with the food, in mastication, and collected in the stomach, which is its reservoir; the pharynx, a muscular and membranous bag, for the reception of the masticated food from the mouth; the œsophagus, a muscular and membranous tube, for conducting the food into the stomach; the stomach, a muscular and membranous bag, or enlargement of the alimentary canal, secreting a fluid or fluids, and reservoir of the salivary and other secretory fluids of the interior surfaces, and in which the food is subjected to the decomposing process, until reduced to a pulpy mass, called *chyme*, consisting of the nutritive and innutritive elements, in a state of mechanical mixture; the duodenum, or second stomach, in which the chymous mass is submitted to the action of the biliary and pancreatic fluids, and in which the nutritive elements begin to separate from the innutritive matters, and to be absorbed by the lacteals, the roots of the animal economy; the liver and pancreas, furnishing bile and a species of saliva, which are mixed with, and act on, the chyme in the duodenum; the jejunum and ileum, or small intestines, in the course of which the separation, begun in the duodenum, is completed, and nearly the whole of the nutritive principles forming chyle are absorbed; and, lastly, the large intestines, a reservoir for all the excrementitious principles, and which, in it, are converted into fæces. The whole of these organs compose the apparatus of digestion, but all are not of equal importance.

The stomach and duodenum are the most eminent organs, and those whose condition exercises the greatest influence over the powers of digestion. This apparatus is intimately connected, and a natural state of each of its parts, and a due exercise of the function of each, are essential to the healthy, undisturbed performance of digestion. This connection is maintained through the ganglionary system of nerves, which not only unites these organs together, but combines them with all their congeries, appropriated to the perfect elaboration of the nutritive and sustaining principles of the economy.

The stomach is the centre of the digestive apparatus, and may be regarded in nearly the same view, for the whole of the organs are connected with individual nutrition. It owes this character to its intimate union with the great solar plexus, the centre or brain, if it may be so termed, of the ganglionary system, regulating the nutritive functions. It is also immediately associated with the brain, through the medium of the eighth pair, or pneumo-gastric nerves, and thus is placed in relation with the exercise of the moral and intellectual faculties. The stomach is consequently exposed to be disordered in its functions by violent impressions from these faculties, as they are also liable to be affected by the disordered conditions of the stomach. It is necessary to have these diversified connections pointed out, to possess a clear understanding of the numerous and very different sources from which disturbances reach the process of digestion.

A few words will now be necessary as to digestion itself. It is not all substances that are fitted for aliment, and are susceptible of digestion. Food is intended for the renovation of the body. It must consist of the same elements as the animal structure, and be capable of becoming organized and living. It must then contain, at least, three elementary animal principles—hydrogen, carbon, and oxygen; and much of it contains, also, a fourth—azote. These elements form secondary compounds, in which state alone they constitute aliment: such are albumen, fibrin, gelatin, osmazome, oil, engan, farina, mucilage, and other animal and vegetable compounds. In all these substances, the molecules are easily separable without being chemically decomposed, which is one of the primary requisites of digestibility, and to effect which is the chief object of digestion. The masticated and insalivated food passes into the stomach. Here it is macerated in the saliva collected in the stomach, and in the proper liquid secreted by the villi of the gastric mucous membrane, at a temperature of 104° Fahr. This liquor is called *gastric juice*. Its true nature is not accurately determined, but, as far as examination has ascertained, it resembles saliva mixed with a small portion of lactic or muriatic acid. The stomach, in a healthy state, always contracts on its contents, so that its parietes, in digestion, are always in contact with the food. During digestion, the stomach has a constant vermicular motion, its muscular fibres contracting, successively, from the smaller to the larger end. The food is thus agitated, acquires a rotatory movement, and is mingled with the fluids of the stomach. In a short time, the change accomplished in the stomach commences; it becomes pulpy, and then reduced to a semi-fluid of a light, grayish colour. From the uniform pressure of the stomach, the solid and most resisting portions are forced into the centre, while the digested and more fluid matter is found on the surface, and is gradually carried, by the contraction

of the muscular fibres, into the duodenun. W. Phillip, and others, have been led to suppose, from this circumstance, that the food in contact with the parietes of the stomach was alone digested; but it is a mere physical result, as uniform pressure in every direction, on a mass of different consistency, will always drive the most fluid to the circumference.

The pulpy, grayish substance resulting from the stomachic digestion, is called *chyme*. When examined with the microscope, it is found to consist of an immense number of transparent globules, of various sizes, intermixed with undissolved fragments of the fibres of the alimentary substance. When food is masticated, and macerated for a few hours in simple saliva, it is found to present exactly the same appearances as the chyme of the stomach. The chyme, having passed into the duodenum, meets with the pancreatic liquor and the bile. What are the positive changes induced by these fluids, certainly is not accurately known. The acids of the chymous mass are neutralized by the alkaline principles of the bile, the picromel and colouring matter of which appear to coalesce with the unassimilable principles of the food, and assist in their conversion into fæces. A chemical modification, in some of the alimentary elements, may also be effected. It is certain that chyle, or the nutritive principles of which blood is formed, does not appear in the lacteals until after the action of the bile and pancreatic fluid on the chyme, the product of the stomachic digestion.

The action of the stomach on the food is that usually designated as *digestion*, and it is the derangement of this process that is usually expressed by the term *dyspepsia*. The process accomplished in the duodenum is also a true digestion, and the symptoms rising from its disordered state are confounded with those of the stomachic digestion, in the general accounts of dyspepsia. From this sketch of the function of digestion, it is evident, that its most important agents are, 1st, the secreted fluids collected in the stomach; 2d, the contractile movements of the stomach, keeping the alimentary mass in constant agitation, mixing it with the fluids as they are secreted, and removing the portion digested or reduced into chyme; 3rd, the application of the biliary and pancreatic fluids to the chyme in the duodenum; and, 4th, the contractile movements of this viscus.

Most of the derangements of the digestive functions may be traced immediately to a departure from a natural state of some one or more of the above requisites of digestion. But this deviation from the natural order is, itself, an effect. The secretions are products of organs, and all excitement of the secretory organ, beyond the range of healthy action, causes vitiation of the secretion, or its total suspension. The action of the organ, diminished below the physiological range, is attended with other vitiations of the fluid, or the cessation of its secretion. Indigestion, or dyspepsia, is a consequence of both these conditions of the organs furnishing the fluids of digestion. Digestion is a very stimulating process. All functional actions are exciting. The increased demand for secreted fluids renders an augmented action and increase of blood in the furnishing organ, necessary for their production. The presence of the food, drinks, &c., in the stomach, add to the stimulation of digestion. If the stomach of an animal be examined in the act of digestion, the mucous membrane is found of a diffused scarlet colour. The movements of the stomach, essential to digestion, depend on its nervous communications, and especially on the integrity of the eighth pair of nerves. When these are divided, the stomach and œsophagus are paralyzed; the food is no longer agitated and mixed up with the digestive fluids, and it often regurgitates from the stomach into the œsophagus. This experiment proves the influence of the contractile motion of the stomach in the act of digestion. The ganglionic nerves are not less important, though their specific influence cannot as readily be determined.

But in many cases of disease of these ganglions, vomiting, eructations, pain in the gastric region, and impaired digestion, are accompanying symptoms. Through the nervous system, the function of digestion is exposed to numerous disorders from moral impressions, especially those of an agitating character. From the preceding principles, it is evident that dyspepsia or indigestion is not, properly speaking, a disease, but rather a symptom, attached to diseases of the apparatus of digestion, of very various and even opposite character. No specific treatment can, therefore, be laid down for the cure of dyspepsia, but each case requires to be managed according to its peculiar cause and nature. The organ of the digestive apparatus, the most frequently productive of dyspeptic symptoms, is the stomach, and the most usual cause of dyspepsia is its irritation and inflammation.

The stomach is more liable than any other organ to these states, from its direct exposure to so many irritating aggressions, and its intimate sympathetic communications, which make it participate in the irritations of almost every other organ. The subacute and chronic forms of gastric irritation and inflammation, the signs of which have only of late been fully appreciated, are the disorders that in seven or eight cases out of ten, are termed *dyspepsia*. Hence dyspepsia so frequently succeeds to febrile diseases, especially when treated by emetics, drastics, and the improper use of tonics and stimulants, which, although the patient escapes the fever, leave him a martyr to the chronic, disorganizing and perturbating irritations of the gastric mucous membrane. Hence, too, dyspepsia almost inevitably follows continued abuse of the digestive functions, from too highly seasoned or too abundant food, and stimulant drinks. The constant stimulation of the stomach finally becomes pathological or morbid. The simple prolongation of the functional excitement essential to digestion, continued from meal to meal, without permitting the stomach to revert to a state of repose, is sufficient to constitute a morbid state. All functions, for their perfect performance, require alternate periods of repose and activity. Incessant action irritates, inflames, and finally disorganizes the structure of the organs.

A second condition of the stomach, productive of dyspepsia, is the congestion of its mucous tissue. This may be confined to the stomach alone, succeeding to an attack of acute gastritis, or following on its protracted irritation; or it may be an attendant on a general congestion of the whole portal system involving most of the abdominal viscera. Every irritation is attended with an afflux of the circulating fluids into the structure where it is seated, proportioned to its intensity and the vascularity of the structure. This gorged state often continues after the subsidence of the irritation that provoked it, and prevents the resumption of the healthy functions.

It is a state of passive congestion, and often exists in the mucous membrane of the stomach, after attacks of inflammation or acute irritation, and embarrasses its digestive operations. In all the extensive irritations of the alimentary canal, especially when attended with fever, having a paroxysmal character, the great portal system of the abdomen becomes loaded with blood, and congestion of its radical vessels ensues. The functions of the viscera are then disordered, the secretions are defective, and indigestion, costiveness, and their attendant nervous affections, are the necessary consequences of this condition.

A third state of the stomach, a cause of dyspeptic symptoms, is precisely the reverse of the preceding. Asthenia, or diminution of vitality and actions below the healthy degree, occasionally takes possession of the stomach. Its circulation is then deficient, its secreted fluids are defective in quantity or quality, its sensibility is impaired, and digestion is imperfect. It is not probable that gastric asthenia is ever primitive. It succeeds to previous irritation, and is often occasioned by irritation in other organs.—The preceding form a first class of dyspeptic diseases, which, depending entirely on the stomach, may be termed *gastric dyspepsia*. They present characters totally different, and require a very opposite treatment. This class embraces three species.

A second class of dyspeptic diseases is connected with the duodenum and its functions. This viscus, similarly constituted to the stomach, is subject to the same morbid alterations. Its mucous membrane is the seat of irritation, in its various grades, and productive of its usual consequences—augmented irritability, sensibility, perversion of secretions, vitiation of structure, and disorder of function. Duodenic irritation most commonly accompanies gastric irritation, and the symptoms of the two are blended together. It exists, however, in many instances, independently; and then manifests particular symptoms, which are often termed *dyspepsia*. It is, more especially, the chronic irritation of the duodenum, that passes for dyspepsia.

It is not probable that congestion, or asthenia, ever affect the duodenum exclusively to the detriment of its function. When these states prevail, it is in conjunction with similar conditions of the whole digestive apparatus. At least, we have no knowledge of these states limited to the duodenum.

A third class of dyspeptic diseases depend on the nervous organs, which furnish nerves to the digestive viscera. The ganglionic system of nerves, distributed on each side of the spine, from the head to the pelvis, transmits nerves to all the organs connected with the nuritive function. The stomach, especially, is largely supplied from the solar plexus, and it receives, likewise, numerous nervous filaments from the pneumogastric, placing it in connection with the functions of relation.

The offices of the ganglionic system are not ascertained with precision. It is, however, well determined, that diseases of the ganglions disorder the functions of the viscera to which they transmit nerves. Hence arises an order of dyspeptic symptoms, independent of any immediate affection of the stomach, but occasioned by disease in the great solar, or other neighbouring plexus. The disorders of the digestive functions, from this cause, are various. The sensibility of the stomach is sometimes greatly increased, constituting gastrelgia. At other times, the secreted fluids of the stomach are morbidly acid.

The stomach appears, in other cases, to be partially paralysed, and the peristaltic movements necessary for the admixture of the food, and the gastric fluids, and the continuous passage of the chyme into the duodenum, are suspended. At the same time, considerable quantities of flatus collect in and distend the stomach, preventing its action on the food. Mechanical manipulation of the abdomen, and particularly of the epigastrium, after a meal, becomes a substitute for the natural motion of the stomach, expels the wind, and facilitates digestion, that would otherwise be laborious and painful.

Dyspepsia, or indigestion, from this analysis of its modes of production, is seen not to be a disease of uniform character, and depending on an identical state of the digestive organs. It is attached, as a symptom, rather, to a variety of conditions, each of which requires to be managed in its appropriate mode. It is not possible that it can be remedied by any one general mode of treatment, or by any set of specific remedies. The most common causes of dyspepsia are excesses of various kinds, especially in the quantity of food eaten. Most individuals, in this country, err in this respect. Meat at three meals, daily, can be borne only by the most robust frames, and by hard labourers. Persons of a sedentary life require less nutriment; the economy makes less demand on the stomach for supplies; and if it be compelled then to labour, it is at its own loss. Exercise, or the expenditure of the nutritive elements by the economy, and the quantity of food to be digested, must be proportioned to each other, for the preservation of health and the due vigour of digestion.

Good cookery, by rendering food more digestible, is one preservative against dyspepsia. The food, by being rendered tender and pulpy, is reduced to chyme in a shorter period, with a smaller expenditure of the secreted fluids, and less excitement of the stomach, than when it is not properly concocted. The art of long and healthful living will depend on a perfect system of cooking, and a rational mode of eating.

The powers of the stomach differ, in individuals, as much as the force of their muscles; and each one must adopt a mode of nutrition, both as to quantity and quality of food, suitable to the wants of his economy and the digestive capacity of his stomach. The quality of food is a frequent cause of dyspepsia. Tough and badly dressed meats, and crude vegetables, are among the prominent causes of this affliction, as are also hot bread and cakes, heavy and fresh bread, and the immoderate use of hot fluids for breakfast. In enumerating the more common causes of dyspeptic symptoms, we ought not to omit the frequent exacerbations of the malevolent passions, as anger, hatred, envy, jealousy, and, what is not often suspected, excessive indulgence and abuses of the venereal propensity Another fruitful source of the digestive disorders is found in the employment of emetics, and in a frequent resort to saline or drastic cathartic medicines. When a constipated habit prevails, it should always be overcome, if possible, by a laxative regimen, and the aids of purgatives be cautiously and rarely invoked. Above all, we may add, healthful exercise and well ventilated apartments will tend most materially towards preserving the health of those persons in whom a disposition to dyspepsia prevails.

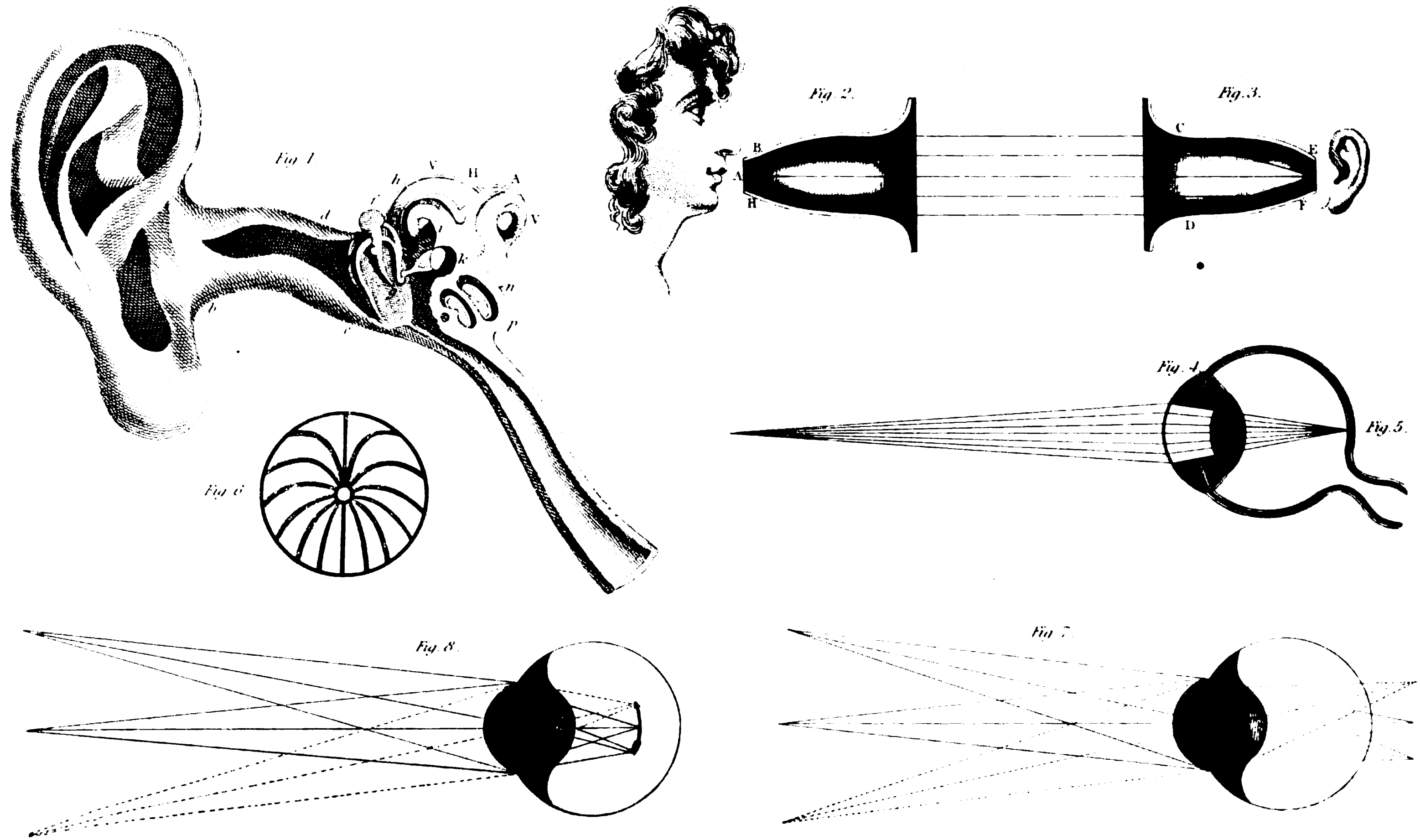


Fig. 1.
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Fig. 4.
Fig. 5.
Fig. 6.
Fig. 8.
Fig. 7.

EAR AND EYE

Dyspepsy. See preceding article.

Dysphonia; a difficulty of speaking.

Dyspnoea; a difficulty of breathing, usually called asthma, which see.

EAGLE, in *astronomy;* a constellation of the northern hemisphere, having its right wing contiguous to the equinoctial.

Eagle, in *architecture*, is a figure of that bird anciently used as an attribute of Jupiter in the capitals and friezes of the columns of temples consecrated to that god.

Ear. The mechanism of *hearing* is simple in its arrangement, and beautifully adapted to the purposes of life. Fitted in an eminent degree to the purposes it is designed to execute, the ear offers an inviting subject to such as are disposed to investigate the minute mechanism of an organ, which contributes remarkably to some of our most exquisite and refined enjoyments. Whoever has witnessed and attentively observed the distressing effects arising from a loss, or diminution of its sensibility, will readily acknowledge that such deprivation throws us at a distance from our fellow-creatures, and, in the present state of society, renders us more solitary beings than the loss of sight itself. Though the rapid glance of the eye, the immense distance to which it enables us to carry our perceptions, and the extended circle it embraces, have given rise to some of our most pleasurable and refined sensations; though it has brought us acquainted with objects which seemed ever placed far beyond our reach; still, the more humble sense which we are now considering, the more confined dominion of the ear, has contributed most efficiently to the every-day happiness of life. It enables us to hold communication with our fellow-creatures; to improve and exalt our understandings by the mutual interchange of ideas; and thus to increase the circle, not only of our physical, but of our moral relations. The charms of eloquence, the pleasure resulting from the concord of sweet sounds, inexplicable perhaps as it remains, are other sources of intellectual enjoyment, which contribute to place this sense among the most delightful as well as the most important we possess. Whatever, therefore, by explaining its structure, or examining its functions, can lead us to improve its natural, or restore its disordered sensibility, cannot be a subject of trivial moment. Our more immediate object is to consider the human ear, observing only, that the structure of the organ, being suited to one great end, is in all cases fundamentally the same; its different forms and varieties depending on the peculiar economy and abode of each individual creature.

The organ of hearing, in its simplest form, consists of the expansion of a nerve, gifted with peculiar sensitive qualities, over the surface of a delicate membrane. In man and the more perfect animals, there is an additional apparatus connected with this, the design of which is supposed to be that of collecting and modifying those pulses of sound which are finally to be impressed on the nervous pulp. In man this apparatus consists of a piece of cartilage, seated externally to the head, which contracts into a funnel leading to the internal parts. The bottom of this tube is truncated obliquely, and its aperture closed by a firm membrane stretched across it, which separates this external part of the ear from the succeeding, or middle portion of the organ. Beyond, or on the opposite side of this membrane, we meet with a small cavity, hollowed out in bone, which has been termed the barrel of the tympanum. Of the several openings into it, there is one more particularly demanding our attention here. It is the internal aperture of a tube, the other extremity of which opens at the posterior part of the nose, behind and above the palate. By means of this communication, the external air is admitted into the chamber, and equipoises the weight of the atmosphere on the other side of the membrane. Across the cavity there is extended, though by no means in a straight line, a series of little bones, the exterior one of which is attached to the membrane we have just mentioned, the most internal of the set being firmly connected with another membrane, which, in conjunction with it, shuts up the entrance to a still more deepened cavity, called the labyrinth of the ear. This last hollow, excavated as it were in the solid bone, consists of a middle portion of irregular figure, and of different channels, which proceed from it in various directions, and, finally, return, with the exception of one only, to the same chamber. All these passages are lined by a membrane, on which the sentient extremity of the auditory nerve is expanded in different shapes; from these it is collected into one trunk, and goes on to join a particular part of the brain, and thus completes the communication between the external agent and the sensorium.

The anatomy of the external ear may, however, be best understood by referring to the illustrative engraving, *figure* 1, plate of the *Ear* and *Eye*.

The meatus externus is seen detached from the bone at *b*. The oblique direction of its internal end is shown at *d e*, the membrana tympani stretched on its bony ring, and bulging inwards.

f g h, the malleus: *f*, the handle or process attached to the membrana tympani; *g*, the long process; *h*, the head.

i k, the incus: *i*, the short leg or process; *k*, the long process.

m, the stapes.

V H A, the curved labyrinth: *n p*, the cochlea; *n*, its beginning, its termination at *p*; this is followed by the vestibule; V, the bony case of the anterior, or smaller of the semicircular canals; H, the posterior, or largest semicircular canal; A, the outer, or smallest canal.

The external part of the ear is differently formed in different animals; and admirably suited to their various situations and habits. In man, it is close to the head, but so formed as to collect the various pulses with great accuracy; in other animals it is more simple, where less accuracy is required, but it is in general much larger, having the appearance of an oblong funnel; and this gives them a greater delicacy of hearing, which was necessary for them.

Dr. Savart considers the external ear as an important auxiliary to the tympanum, capable also of entering into vibration by communication, and having for its principal function to present always to the air (by the various directions and inclinations of its surfaces to one another) a certain number of parts, upon which the undulations of the air shall fall perpendicularly. The little muscles which are inserted in it, he thinks, contribute by their action to increase its tension, and render it more elastic.

Within the cavity of the tympanum are placed four

small bones, which facilitate the hearing: the first is the malleus, or hammer, so called from its shape: the upper part of its round head rests upon the concavity of the tympanum, from whence the handle is extended down, along the membrane of the tympanum. This bone has several muscles, which move it in different directions, and cause it to stretch, or brace the membrana tympani, when we wish to hear with accuracy.

Connected with the malleus is another small bone called the incus, or anvil, which is connected with another called the stapes, or stirrup, from its shape. These two bones are connected by a small oval-shaped bone called os orbiculare, placed between them: the whole forming a little chain of bones.

The stapes, or stirrup, has its end of an oval form, which fits a small hole called fenestra ovalis, in that part of the ear called the labyrinth, or innermost chamber of the ear.

The labyrinth consists of three parts: first, the vestibule, which is a round cavity in a hard part of the os petrosum; secondly, the semicircular canals, so called from their shape, which, however, is not exactly semicircular; thirdly, the cochlea, which is a beautifully convoluted canal, like the shell of a snail. This part has a round cavity called fenestra rotunda, which is covered with a thin elastic membrane, and looks into the tympanum.

The vestible, semicircular canals, and cochlea, the whole of which is called the labyrinth, form one cavity, which is filled with a very limpid fluid resembling water, and the whole lined with a fine delicate membrane, upon which the auditory nerve is expanded, like the retina upon the vitreous humour of the eye. This beautiful apparatus was lately discovered by an Italian physician, Scarpa. The auditory nerve is a portion of the seventh pair, which is called the portio mollis, or soft portion.

There is one part of the ear still to be described; namely, the Eustachian tube, so called from Eustachius, the anatomist, who first described it.

This tube opens by a wide elliptical aperture into the tympanum behind the membrane; the other end, which gradually grows wider, opens into the cavity of the mouth. By this canal the inspired air enters the tympanum to be changed and renewed; it likewise serves some important purpose in hearing, with the nature of which we are yet unacquainted. It is certain that we can hear through this passage, for if a watch be put into the mouth, and the ears stopped, its ticking may be distinctly heard; and in several instances of deafness this tube has been found completely blocked up. Though the use of the Eustachian tube has been doubted, as conveying sound by the mouth, yet a simple experiment will convince us, that it has some influence in this respect; thus, if a deaf person is to converse with another, and a wire or other medium of communication is made to pass to the mouth of each, by placing its extremity between the teeth, the deaf person will hear the conversation better than without this assistance, which certainly proves, that part of the vibrations of sound is carried along the wire into the mouth, and applied to the ear through the Eustachian tube in the throat; while a part also reaches the ear externally, and is collected in the auricle in the usual manner. We have seen people quite deaf to outward sounds, enjoy a concert on the piano-forte, by means of a long narrow bar of wood placed on the instrument, the opposite end being grasped between the teeth.

We have now to notice the labours of M. Savart, who has paid considerable attention to the anatomy and uses of the tympanum.

By a series of experiments, which, fortunately for the cause of humanity, have not been verified in this country, he ascertained that the membrane of the tympanum exactly resembled in its effects the vibrations of a drum, or plate. (See Acoustics.)

That the membrane of the tympanum may justly be compared with an ordinary membrane acted upon by communicated vibrations. This was proved, by submitting the real ear to the following experiment:—after having removed the temporal bone, he made with the saw a section parallel to the external surface of the membrane, so as to lay it open, and to be enabled to cover it with sand: the sand was observed to be slightly put in motion, when a vibrating plate was brought parallel with the membrane, and very near its surface; but it was impossible, from its limited extent, and particularly on account of its form, to prove the existence of any distinct nodal line. The existence of the motions was rendered much more evident, by substituting for the human tympanum the drum of a calf's ear.

He observed, also, that when the internal muscle of the malleous acted, and, consequently, that when the membrane was tightened, it was more difficult to produce evident motions in the grains of sand; so that the uses of this little muscle appear, like those of the iris, to consist in preserving the organ from impressions too intense, which, under certain circumstances, it might otherwise receive.

The membrane of the tympanum may be considered as a body put in motion by the air, and performing always a number of vibrations equal to that of the body which has produced the oscillations in the air; but, besides, as the direction of the molecular motions of the membranes, and generally of all bodies, continually vary with the direction of the vibrations of the body directly put in motion, it may be presumed that it is by this means that we are able to judge of the direction of the sound, when it arrives without having been reflected.

The following experiment shows, that if the auditory passage, the concha, and the bell of the ear, serve to render the aerial oscillations more intense, they also are of use to reciprocate the vibrations of the air, and to transmit them to the membrane of the tympanum, with the same degree of force, whatever may be their direction. A very wide conical tube was formed of thin pasteboard, and to its smaller end a thin and tended membrane was firmly fastened: on bringing in a parallel direction to the upper and external surface of this membrane, when covered with sand, a vibrating plate, the grains of sand were but slightly put in motion; but on placing the plate near the large orifice of the tube, they became strongly agitated. Another conical tube was opposed by its summit to the preceding, but without touching the membrane, and afterwards the plate was put in vibration at the larger orifice of each of the tubes: it was observed that the communicated motions were incomparably more energetic when the aerial undulations arrived through the tube which was in immediate contact with the membrane, than when they arrived through that which did not touch it.

Another experiment shows the important influence

which the malleus, fastened upon the internal surface of the membrane of the tympanum, exercises upon the nature of its motions. If a small wooden rod, reduced at its edges, be fixed on a stretched membrane, so that it may extend itself from the centre to the circumference, or even beyond, the figures produced by the membrane will be modified by the presence of the little rod, and the latter will be caused to vibrate so strongly, that very distinct nodal lines will be produced in it, even when its dimensions are rather considerable.

It appears then from this, that the malleus fulfils at the same time two distinct functions: first, it modifies, by means of its muscles, the tension of the membrane, in order to preserve the organ from over-intense impressions, and to dispose it conveniently to receive the weakest impressions; and, secondly, it reciprocates the motions of the membrane, and communicates them to other parts. Since this bone is in immediate contact with the incus, and the incus communicates with the lenticular bone, and, by its means, with the stapes, it is evident that the membrane of the tympanum cannot vibrate, without producing corresponding oscillations in the membranes of the fenestra ovalis. The mechanism which causes the tension of the latter membrane, and preserves the soft parts contained in the labyrinth from intense impressions, may be illustrated by an experiment. Had the membranes which close the entrances of the labyrinth been in immediate contact with the atmospheric air, their elastic state would have been continually influenced by the changes of temperature of that fluid. It may, therefore, be presumed, that the use of the membrane of the tympanum is to prevent the direct contact of the atmospheric air, and that the case of the drum and the mustoid cells form a kind of receptacle, in which the air, already warmed, coming from the mouth through the Eustachian tube, acquires the constant temperature of the body, in order to establish, before the apertures of the labyrinth, an atmosphere, the properties of which are invariable: so that it is probable that the great temporal artery, separated from the case of the drum only by a very thin bony partition, is of some importance in the mechanism of audition.

In *deafness*, the auditory nerve first fails to detect the soft distinctions of sound; vibrations must be stronger and stronger, to convey through the medium of a thickened tympanum, impressions to the brain. But while the faculty of hearing declines, the nerves may be occasionally so much excited, that they will detect sounds with their wonted acuteness. A very striking instance of this is apparent in the case of a gentleman, so deaf that he could only hear the voice when raised to its highest pitch, and yet, when riding in a carriage rattling along the streets, he could hear common conversation without difficulty. It would, by this, appear, that the powers of hearing, although impaired, yet being greatly excited by this discordant din, and the tympanum or drum of the ear placed in more than ordinary tension, the sense was partially restored.

Dr. Wollaston discovered the very singular fact, that there were persons who never felt any defect in their hearing, and who yet could not hear certain sounds, which others perceive distinctly.

It is well known, that persons affected with slight deafness, hear sharp sounds much better than those which are grave and low. They distinguish the voices of women and children, from their acuteness, much better than the lower tones of men's voices. This fact is acted upon practically, as it may be remarked, that those accustomed to speak to deaf people use a shriller tone of voice, rather than merely a louder tone than common.

This partial deafness may be artificially produced, by shutting the mouth and nose, and exhausting the air in the Eustachian tube, by a forcible attempt to take breath by expanding the chest. When this is carefully done, so that the exhaustion of the air behind the drum of the ear is as complete as possible, the external air is felt strongly, and even painfully, pressing on the drum; and the ear becomes insensible to low sounds, though shrill sounds are as readily perceived as before.

After the ear is brought into this state, it will remain so for some time, without continuing the painful effort to take breath, and even without stopping the breath; for, by suddenly discontinuing the effort, the end of the tube will close like a valve, and prevent the air from getting into the drum. The act of swallowing will open the closed tube, and restore the ear to its wonted feeling.

When the ear is thus exhausted, if we attempt to listen to the sound of a carriage passing in the street, the rumbling noise cannot be heard, though the rattle of a chain or loose screw remains as easily heard as before. At a concert the experiment has a singular effect: as none of the sharper sounds are lost, and the great mass of the louder sounds are suppressed, the shriller ones are consequently so much the more distinctly heard, even to the rattling of the keys of a bad instrument, or the scraping of catgut unskilfully touched.

On examining the external ear in *quadrupeds*, it is found to resemble the oblique section of a cone, from near the apex to the base. Hares, and other animals exposed to danger, and liable to be attacked by men, or beasts of prey, have large ears, and they are particularly directed backwards; while their eyes at the same time, full and prominent, warn them of any danger in front. Rapacious animals, on the contrary, have their ears placed directly forwards, as is observable in the lion, the tiger, the cat, and others.

All animals, as far as we know, possess the sense of hearing: it was formerly doubted with respect to fishes.

The organ of hearing in fishes was first discovered by the late Mr. John Hunter; and is prosecuted at a considerable length, in his work on the organ of hearing in fishes, by the late Professor Monro, of Edinburgh. Thus the modern researches and discoveries in comparative anatomy have sufficiently established their possession of this sense, as well as the other classes.

In cray-fish, and the sepiæ, the organ is most simple, consisting of a small cavity or vestibule, and a single membranous tube. The spinous fishes, in addition to the hollow of the vestibule, and membranous bag containing the lappilli, are provided with semicircular canals; whilst, in the osseous fishes, the whole is enclosed by bone. To the labyrinth of the serpent tribe, which is very similar to the internal ear of the cartilaginous fishes, there is added an officulum, closing the fenestra ovalis. In one of this order, and in almost all the four-footed reptiles, the membrana tympani is furnished with this officulum.

In prosecuting our inquiries farther, the ear has

been discovered in insects; it lies at the root of their antennæ, or feelers, and can be distinctly seen in the lobster, and some others of the larger kind.

In the sea-tortoise, the frog, and other amphibious animals, its structure is peculiar, by there being no external meatus, but an expanded Eustachian tube, at the back part of the roof of the mouth, near where the under and upper jaws articulate. This tube has a winding course behind the upper jaw, and leads to a large cavity, resembling the cavity of the human tympanum, covered by the skin of the temple and a tough substance. The latter then passes into the bottom of the tympanum, and next into a smaller cavity filled with a watery humour, and last it opens into a third cavity, having three semicircular canals, and a sac containing a soft cetaceous substance, on the membrane of which are distributed the nerves. Thus, making a comparison of it with the human ear, the tough substance, or cartilaginous body, supplies the place of the small bones of our ear, and the membrane to which it is connected is analogous to the membrane of the foramen ovale. The sac, and semicircular canals and nerves, exactly resemble the human labyrinth, or internal ear.

Ear-trumpet. The mode of constructing a *trumpet* for the purpose of conveying sounds to a distance was well known to the ancients. Its invention is, however, usually ascribed to Sir Samuel Morland, who called it the *tuba Stentorophonica.* An account of this instrument was published at London in 1671, in which the author relates several of his early experiments; the result of which was, that a speaking-trumpet constructed by him, five feet six inches long, twenty-one inches diameter at the greater end, and two inches at the smaller, being tried at Deal Castle, was heard at the distance of three miles, the wind blowing from the shore. Kircher, in his *Phonurgia Nova,* published in 1673, says, that "the tromba, published last year in England, he invented twenty-four years before, and published in his *Misurgia*:" he adds, that "Jac. Albanus Ghibbisius and Fr. Eschinardus ascribe it to him; and that G. Scottus testifies of him that he had such an instrument in his chamber in the Roman college, with which he could call to, and receive answers from, the porter.

In a speaking-trumpet, the sound in one direction is usually supposed to be increased, rather by the reflection of the sound than by its greater intensity in one direction; and as the real action of the instrument, or the true motion of the air through it, is not generally understood, different persons, according to their particular conceptions of the case, have recommended peculiar shapes for the construction of such trumpets: some suggest a conical shape; others, that which is formed by the rotation of certain curves round their axis; others, again, have recommended an enlargement or two of the cavity in the length of the trumpet; but that which has been most commonly recommended, as the best figure for such a trumpet, is generated by the rotation of a parabola about a line parallel to the axis.

The true physical explication of the speaking-trumpet appears to have been first given by Professor Leslie. "In the case of articulate sounds," says he, "the confining of the air does not affect the pitch of voice, but it augments the degree of intonation. The lateral flow being checked, that fugacious medium receives a more condensed and vigorous impulsion. As the breath then escapes more slowly from the mouth, it waits and bears a fuller stroke from the organs of speech. But the speaking-trumpet is only an extension of the same principle; its performance does certainly not depend upon any supposed repercussion of sound; repeated echoes might divide, but could not augment the quantity of impulse. In reality, however, neither the shape of the instrument, nor the kind of material of which it is made, seems to be of much consequence. Nor can we admit that the speaking-trumpet possesses any peculiar power of collecting sound in one direction, for it is audible distinctly on all sides.

To put the construction of this instrument in the plainest and simplest point of view, we have only to suppose the lips to be enclosed at A, *Fig.* 2, Plate of the *Ear* and *Eye*, and, as such, that the aerial pulse is directed parallel to the axis of the tube. If this system of enclosure were not resorted to, the air would expand itself in every direction, instead of being propelled in the required line; but, the instant the wave spreads, it is received by the reflecting surface B, from whence it impinges at C, and thence, by repeated reflection, to D, E, and F. The direction it has now acquired will be indicated by the lines F H, which are parallel to the axis of the tube, so that by this method a concentration of sound takes place, which could not be effected by any other means.

The *ear-trumpet* differs but little from the acoustical apparatus just described, as a reference to the diagram *Fig.* 3, Plate of the *Ear* and *Eye*, in which two trumpets are seen placed opposite to each other, will readily show. In the one case, the lines show the way in which the aerial pulses are propelled from the lips in any required direction; while, in the other, they are collected, and received by the organs of hearing.

Mr. Gough has tried several experiments on ear-trumpets, which are very deserving of notice: the first experiments were made with a view to determine the degree in which hearing was assisted by the vibrations excited in the metallic shell of the trumpet, and conveyed by it to the orifice of the auditory duct. The result of these experiments was, that absolute contact of the thing producing the sound, with the apparatus for the ear, was necessary, in order that the latter should produce its effects. The ticking of a watch, the scratching of a pin, or even that of a twisted piece of paper, was conveyed well by the instrument, when in contact with it (every other avenue for sound being carefully prevented), but the sound was no longer heard when the watch was moved the smallest distance from the instrument, or when the other noises were made in similar circumstances.

Earth. The form and motions of the planet on which we live, and on which is concentrated so many of our enjoyments, will be examined in this article. That it is a "fair and beautiful earth to look upon" must be admitted by every unprejudiced person, and it has, as far as we have any means of judging by our own feelings, many advantages over the other planetary bodies.

To an observer who possesses an unobstructed view, the earth presents the appearance of a circular plain, on the circumference of which the heavens appear to rest. Accordingly, in remote antiquity, the earth was regarded as a flat, circular body, floating on the wa-

ter. But the great distances which men were able to travel soon refuted this limited idea as an optical illusion; and, even in antiquity, the spherical form of the earth began to be suspected. On this supposition alone can all the phenomena relating to it be explained. A sphere of such great magnitude as our earth, surrounded by a stratum of air, or the visible firmament, must present to the eye of an observer on a plain, the appearance just described.—But how could the earth appear, from every possible position, as a surface bounded by the firmament, if it were not a sphere encircled by it? How else could the horizon grow wider and wider, the higher the position we choose? How else can the fact be explained, that we see the tops of towers and of mountains, at a distance, before the bases become visible? But, besides these proofs of the sphericity of the earth, there are many others, such as its circular shadow on the moon during an eclipse, the gradual appearance and disappearance of the sun, the inequality of day and night, the changes in the position and course of the stars, and the gradual disappearance of some and appearance of others, as we go from the equator to the poles. Finally, if the earth were not spherical, it would be impossible to sail round it, which is frequently done. The cause of the earth's sphericity is very evident, if we consider it as having been, at first, a yielding mass, capable of assuming any form: then, by the force of gravity, every particle contained in it tending towards the common centre, the globular form is the necessary consequence. The earth is not, however, an exact sphere, but is flattened at the poles. Philosophers were first led to observe this by the variations in the vibrations of the pendulum, under the equator, and near the poles.

It was found that the pendulum performed its vibrations slower, the nearer it approached the equator, and hence was inferred the variableness of the force of gravity. This was easily explained on the theory just mentioned, because, the circle of daily revolution being greatest at the equator, all bodies revolve proportionally faster there than at the poles, so that the centrifugal force is greater, and the force of gravity less, than at other parts of the earth's surface; and because at the equator, the centrifugal force is exactly opposed to that of gravity, but towards the poles, being oblique to it, produces less effect. From these observations it was justly inferred, that the earth is a sphere, flattened at the poles, or a spheroid; and this form was satisfactorily accounted for by the fact that the particles of a yielding mass, which revolves on its own axis, depart from the poles and tend to the centre, by which the poles are, of course, flattened, and the middle elevated. Various measurements have put this beyond all doubt. (See Degree, Measurement of.)

Another important desideratum for a more intimate acquaintance with the earth was, to fix its magnitude. The labours of the ancients, in this respect, were all fruitless, owing to their want of suitable instruments. Accurate results were first obtained in the year 1615, Willibord Snellius, a Dutchman, first struck into the true way, and measured an arc of a meridian from Alcmaar to Leyden and Bergen op Zoom, by means of triangles. After him, the measurements of Picard, and the later ones of Maupertuis, approximated nearer the truth. These made the circumference of a great circle of the earth 25,000 miles. But it is to be remarked that, in this calculation, the earth is regarded as a perfect sphere. Farther measurements of all parts of the surface of the earth will be necessary, to find rigidly and accurately, the true magnitude of it.

If we take a view of our earth in its relation to the solar system, astronomy teaches us that, contrary to appearances, which make the sun revolve about the earth, the earth and ten other planets revolve about the sun, and, being themselves opaque bodies, receive from the sun light and heat.

The earth completes its revolution round the sun in about 365 days and 6 hours, which forms our common year. The orbit of the earth is an ellipse, with the sun in one of its foci. Hence the earth is not equally distant from the sun in all parts of the year: its least distance is estimated at 93,336,000 miles, and its greatest, at 95,484,572, making a difference of more than 2,000,000 of miles.

In winter, we are nearest the sun, and in summer, farthest from it; for the difference in the seasons is not occasioned by the greater or less distance of the earth from the sun, but by the more or less oblique direction of the sun's rays. The length of the path travelled over by the earth is estimated at 567,019,740 miles, and, as this immense distance is passed over in a year, the earth must move 17 miles a second—a rapidity so far exceeding our conceptions, that it gave very just occasion to the pleasant remark of Lichtenberg, that, while one man salutes another man in the street, he goes many miles bareheaded without catching cold. Besides this annual motion about the sun, the earth has also a daily motion about its own axis (according to mean time, in 23 hours, 56 minutes and 4 seconds). This diurnal revolution is the occasion of the alternation of day and night. But as the axis on which the earth performs its diurnal rotation forms, with its path about the sun, an angle of 23½ degrees, the sun ascends, from March 21 to June 21, about 23½ degrees above the equator towards the north pole, and descends again towards the equator from June 21 to September 23; it then sinks till December 21, about 23½ degrees below the equator, towards the south pole, and returns again to the equator by March 21. This arrangement is the cause of the seasons, and the inequality of day and night attending them, which, for all countries lying beyond the equator, are equal only twice in the year, when the ecliptic coincides with the equator. The moon, again, revolves about the earth, in a similar elliptical path, in 28 days and 14 hours. Copernicus first laid down this as the system of the universe.

To the physical knowledge of the earth belongs, especially, the consideration of its surface and its interior. The earth's surface contains above 196,000,000 square miles, of which scarcely a third part is dry land; the remaining two thirds are water. Of the surface of the earth, Europe comprises about one 54th part; Asia, one 14th; Africa, a 17th; and America, a 16th. The islands of the Pacific, taken together, are somewhat larger than Europe. The population of the whole earth is estimated at from 800 to 1000 millions. The interior of the earth is entirely unknown to us, as the depth to which we have been able to penetrate is nothing in comparison with its diameter. Many modern speculators are of opinion that the interior is composed of a metallic mass. Respecting the origin and gradual formation of the earth, there are various hypotheses.

The earth has two motions, the daily motion round its axis, and the yearly motion in its orbit round the sun. The theory of the motion of the earth has become memorable in the history of the human mind, showing, as it does, a marked ability in man to resist the impressions produced by appearances, and to believe the contrary of that which had been believed and taught for many centuries.

The theory of Copernicus not only founded the modern system of astronomy, but made men eager to examine other articles of their creed, after they were thus convinced that they had erroneously taught and believed the earth to be stationary for 6000 years. All the opinions of the ancients respecting the motion of the earth were speculative hypotheses, arising from the Pythagorean school, which, as we know, considered fire the centre of the world, round which all was moving. Thus we ought to explain the passage of Aristarchus of Samos, mentioned by Aristotle in his *Arenario*. Aristarchus, as a Pythagorean, held the idea that the earth revolves round its axis, and, at the same time, in an oblique circle round the sun; and that the distance of the stars is so great, that this circle is but a point in comparison with their orbits, and therefore the motion of the earth produces no apparent motion in them. Every Pythagorean might have entertained this idea, who considered the sun or fire as the centre of the world, and who was, at the same time, so correct a thinker, and so good an astronomer, as Aristarchus of Samos. But this was not the Copernican system of the world. It was the motions of the planets, their stations, and their retrogradations, which astronomers could not explain, and which led them to the complicated motions of the epicycles, in which the planets moved in cycloids round the earth.

Aristarchus lived 280 B. C., Hipparchus, the great astronomer of antiquity, 150 B. C., therefore 130 years later. At this time, all the writings of Aristarchus were extant, and, had the Copernican system been set forth in them, Hipparchus would not have despaired of explaining the motions of the planets. The same is true of Ptolemy, in whose *Almagest*, the most complete work of antiquity on astronomy, this system is not mentioned in the account of Aristarchus. Every Copernican speaks of the motion of the earth, but not every one who speaks of the motion of the earth is a Copernican. Copernicus was led to the discovery of his system by a consideration of the complicated motion of the planets, and, in the dedication of his immortal work, *De Revolutionibus Orbium*, to pope Paul III., he says, that the truth of his system is proved by the motion of the planets, since their successive stations and retrogradations are the simple and necessary consequence of the motion of the earth round the sun; and we need not take refuge in the complicated epicycles.

Copernicus did not live to see the persecutions which the Roman Catholic priests raised against his system. They began only 100 years later (about 1610), when the telescope was invented, when the moons of Jupiter and the phases of Venus were discovered, and, by these means, the zeal for astronomy had been highly excited. Every city in Italy was then a little Athens, in which the arts and sciences flourished. Galileo obtained high distinction, and defended the new system of the world. The Roman Inquisition summoned him before its tribunal, and he was compelled to abjure this theory. (See GALILEO.) The general sympathy for the fate of this astronomer increased the popularity of the system, and it was as violently defended on one side as it was attacked on the other.

Among the arguments against the motion of the earth, it was alleged, that a stone, falling from a tower, did not fall westward of the tower, notwithstanding this had advanced eastward several hundred feet during the four or five seconds of the fall of the stone. Copernicus had answered justly: the cause of its remaining near the tower is, that it has the same motion eastward, and, in falling, does not lose this motion, but advances with the earth. Galileo said the same, and asserted that a stone, falling from the top of the mast of a vessel, at full sail, falls at the foot of the mast, notwithstanding the mast advances, perhaps 10 or more feet during the fall. Gassendi tried these experiments in the harbour of Marseilles, and the stones fell at the foot of the mast, notwithstanding the vessel was under full sail. Galileo therefore maintained, that it was impossible to draw any conclusion concerning the motion of the earth from such experiments, since bodies would fall on the earth in motion precisely the same as on the earth at rest.

In 1642, Galileo died. In the same year, Newton was born. He proved, in 1679, that the opinion of Galileo was erroneous, and that we certainly could try experiments on the motion of the earth; that the balls would not deviate westward, but would fall a little eastward of the plumb-line, about a half inch at the height of 300 feet. The cause is this: since the top of the tower is at a greater distance from the axis of the earth than its base, the centrifugal force must be greater at the former point than at the latter; the ball, in falling, does not lose this impulse, and, therefore, advances before the plumb-line, which strikes the foot of the tower, since it has a less impulse eastward. This hint, given by Newton, was followed by Hooke. He tried experiments on the motion of the earth, at a height of 160 feet, and asserts that he succeeded. The academy appointed a committee, Jan. 14, 1680, in the presence of which he was to repeat his experiments. Probably they were not satisfactory, since they have never been mentioned in the *Philosophical Transactions*, and were entirely forgotten. Only 112 years later, a young geometrician in Bologna, Guglelimini, attempted to repeat these experiments, which had been considered very difficult by astronomers, in the tower Degli Asinelli, in that city, at a height of 240 feet. After having surmounted all difficulties, he succeeded in causing the fall of 16 balls, which perceptibly deviated eastward. But Guglielmini, committed an error in not suspending the lead every day when he tried his experiments, of which he often made three or four in one night. He did not drop the plummet until after he had finished all his experiments, and as it did not come to a perpendicular position until six months, on account of stormy weather, the tower in the mean time was a little bent, the point at which the plummet should have fallen was altered, and his experiments were lost. This happened in 1792. Benzenberg, a German, performed similar experiments in 1804, in Michael's Tower, in Hamburg. He let fall 30 balls, from the height of 235 feet: the balls deviated from the perpendicular four lines eastward. But they deviated, at the same time, 1½ line south-

ward, probably owing to a gentle draught of air in the tower. He repeated these experiments in 1805, in a coalpit, at Schlebusch, in the county of Mark, at the height of 260 feet: there the balls deviated from the perpendicular five lines eastward, just as the theory of the motion of the earth requires for the latitude of 51°, but neither southward nor northward. From these experiments, Laplace calculated that the chances are 8000 to 1, that the earth turns round its axis.

The invention of the telescope, by means of which the rotation of Jupiter was soon observed, but still more Newton's discovery of universal gravity, and of the nature of the celestial motions, established the theory of the motion of the earth; and, in modern times, no man of intelligence doubts it any longer. The French General Allix, however, endeavoured to prove that the motion of the planets could not depend on the law of gravitation.

The flattening of the earth (see DEGREE, MEASUREMENT OF), and the diminution of gravity in the vicinity of the equator, proved by the experiments of Richers and others on the motion of the pendulum in the equatorial regions (see PENDULUM), also give as convincing proofs of the rotation of the earth, as the aberration of light affords of the revolution of the earth round the sun. Thus the human intellect has triumphed over the evidences of sense, and the opposition of authority.

EARTH-BANKS, in *rural economy*, are a kind of fence, very common in the vicinity of London, and in several other parts of England; where stones cannot easily be procured, they are preferable to other fences, both for soundness and durability.

EARTHQUAKE; a shaking of certain parts of the earth's surface, produced by causes not perceivable by our senses. This motion occurs in very different ways, and with various degrees of violence. Sometimes it is perpendicular, throwing portions of the ground into the air, and making others sink. Sometimes it is a horizontal, undulating motion, and sometimes it appears to be of a whirling nature. Sometimes it is quickly over; sometimes continues long, or recurs at intervals of weeks, days, or months. At one time it is confined within a small circle; at another it extends for many miles. At one time it is hardly perceptible; at another it is so violent, that it not only demolishes the works of human art, but changes the appearance of the ground itself. Sometimes the surface of the ground remains unbroken; sometimes it bursts open into clefts and chasms; and then occasionally appears the phenomenon of the eruption of gases, and also of flames, with the ejection of water, mud, and stones, as in volcanic eruptions.

The eruptions of proper and permanent volcanoes are preceded by, and proportionate to, the agitations of the earth in their neighbourhood. These observations furnish grounds for the conclusion that earthquakes cannot proceed from external causes, but arise from certain powers operating within the circumference or crust of the earth. Moreover, all the phenomena of earthquakes bear so much affinity to those of volcanoes, that there can hardly be a doubt that both proceed from the same causes, acting differently, according to the difference of situation, or different nature of the surface on which they operate.

A volcano differs from an earthquake, principally, by having a permanent crater, and by the re-appearance of the eruptions in the same place, or in its immediate vicinity. All the other phenomena of a volcano, such as the subterranean thunder-like noises, the shaking, raising, and bursting asunder of the earth, and the emission of elastic fluids, the fire and flames, the ejection, too, of mineral substances, all occur, now and then, more or less, in earthquakes as well as in volcanic eruptions, even when at a distance from active volcanoes; and the genuine volcanic eruptions are, as has been remarked, accompanied or announced by shakings of the earth. All our observations go to prove, that volcanic eruptions, earthquakes, the heaving of the ground from within, and the disruption of it in the same way, are produced by one and the same cause, by one and the same chemical process, which must have its seat at a great depth beneath the present surface of the earth.

The most remarkable earthquakes of modern times are those which destroyed Lima, in 1746, and Lisbon, in 1755; in the latter, 20,000 persons were killed. It extended from Greenland to Africa and America. A similar fate befell Calabria, in 1783, the province of Caracas, in South America in 1812, and Aleppo, in Syria, in 1822. Several earthquakes have taken place quite lately, in South America, one particularly dreadful at Lima. The city of Guatemala, also, was nearly destroyed in the spring of 1830, by earthquakes, which continued five days successively.

EARTHS. The term *earth* is applied, in common life, to denote a tasteless, inodorous, dry, uninflammable, sparingly-soluble substance, which is difficultly fusible, and of a moderate specific gravity. Several of the earths are found in a state of purity in nature; but their general mode of occurrence is in intimate union with each other, and with various acids and metallic oxides. Under these circumstances, they constitute by far the greatest part of the strata, gravel, and soil, which go to make up the mountains, valleys, and plains of our globe. Their number is ten, and their names are *silex*, *alumina*, *magnesia*, *lime*, *barytes*, *strontites*, *zircon*, *glucine*, *yttria*, and *thorina*. The four first have long been known to mankind; the remainder have been discovered in our own times.

Silex exists nearly pure, in large masses, forming entire rocks, as quartz rock, and constituting the chief ingredient in all granitic rocks and sandstones, so that it may safely be asserted to form more than one half of the crust of the earth. Alumina is found pure in two or three exceedingly rare minerals, but, in a mixed state, is well known as forming clays and a large family of rocks, usually called *argillaceous*. Lime, an earth well known from its important uses in society, occurs, combined with carbonic acid, in which state it forms limestone, marble, chalk, and the shells of fish. It exists, also, upon a large scale, in combination with sulphuric acid, when it bears the name of *gypsum*. Magnesia is rarely in a state of purity, but enters largely into the composition of some of the primary rocks, especially of the limestones.

The remaining eight (if we except barytes, which, in combination with sulphuric acid, is often met with in metallic veins) are only known to the chemist as occurring in the composition of certain minerals which, for the most part, are exceedingly rare.

The earths are very similar to the alkalies, form-

ing, with the acids, peculiar salts, and resembling the alkalies, likewise, in their composition. They consist of peculiar metals in combination with oxygen, and compose the greatest part of the solid contents of the globe. They differ from the alkalies, principally, in the following peculiarities: they are incombustible, and cannot, in their simple state, be volatilized by heat; with different acids, especially the carbonic, they form salts, insoluble, or soluble only with much difficulty, and with fat oils, soaps insoluble in water. They are divided into two classes, the alkaline and simple earths. The former have a greater similarity to the alkalies. In their active state they are soluble in water, and these solutions may be crystallized. They change the vegetable colours almost in the same way as alkalies, and their affinity for acids is sometimes weaker and sometimes stronger than that of the alkalies. They combine with sulphur, and form compounds perfectly similar to the sulphureted alkalies. With carbonic acid, they form insoluble salts, which, however, become soluble in water by an excess of carbonic acid.

The alkaline earths are as follow: 1. barytes, or heavy earth, so called from its great weight; 2. strontites; both these earths are counted among the alkalies, by many chemists, on account of their easy solubility in water; 3. calcareous earth, or lime, forms one of the most abundant ingredients of our globe; 4. magnesia is a constituent of several minerals. The proper earths are wholly insoluble in water, infusible at the greatest heat of our furnaces, and, by being exposed to heat, in a greater or less degree, they lose their property of easy solubility in acids. Some of them are incapable of combining with carbonic acid, and the remainder form with it insoluble compounds. They are the following: 1. alumine; 2. glucine, which is found only in the beryl and emerald, and a few other minerals; 3. yttria is found in the gadolinite, in the yttrious oxide of columbium, &c.; 4. zirconia is found less frequently than the preceding, in the zircon and hyacinth; 5. silex.

The earths were regarded as simple bodies until the brilliant researches of Sir H. Davy proved them to be compounds of oxygen with peculiar bases, somewhat similar to those of the alkalies, potassium, and sodium. Some of the heavier of the earths had often been imagined to be analogous to the metallic oxides; but every attempt to effect their decomposition or reduction had proved unsuccessful. After ascertaining the compound nature of the alkalies, Davy submitted the earths to the same mode of analysis by which he had effected that fine discovery. The results obtained in his first experiments were less complete than those afforded with the alkalies, owing to the superior affinity between the principles of the earths, as well as to their being less perfect electrical conductors. By submitting them to galvanic action, in mixture with potash, or with metallic oxides, more successful results were obtained; and a method employed by Berzelius and Pontin, of placing them in the galvanic circuit with quicksilver, terminated very perfectly in affording the bases of barytes and lime, in combination with this metal. By the same method, Sir H. Davy decomposed strontites and magnesia; and, by submitting silex, alumine, zircon, and glucine, to the action of the galvanic battery, in fusion with potash or soda, or in contact with iron, or by fusing them with potassium and iron, appearances were obtained sufficiently indicative of their decomposition, and of the production of bases of a metallic nature.

Thorina, the last discovered earth, was decomposed by heating the chloride of thorium with potassium. The metallic bases of the earths approach more nearly than those of the alkalies to the common metals, and the earths themselves have a stricter resemblance than the alkalies to metallic oxides. Viewing them as forming part of a natural arrangement, they furnish the link which unites the alkalies to the metals. Accordingly, many of the more recent systems of chemistry treat of all these bodies as forming a single group under the name of the metallic class. Still (as Doctor Ure justly remarks), whatever may be the revolutions of chemical nomenclature, mankind will never cease to consider as earths those solid bodies composing the mineral strata, which are incombustible, colourless, not convertible into metals by all the ordinary methods of reduction, or, when reduced by scientific refinements, possessing but an evanescent metallic existence. (For a more particular account of the properties of the earths, and of their bases, consult the articles relating to them, respectively, in this work.)

Easel, in the *fine arts*. The frame on which the picture is placed during the progress of painting.

East; one of the four cardinal points of the world, being the point of the horizon where the sun is seen to rise when in the equator. In Italy, and throughout the Mediterranean, the east wind is called the *levante*.

East India Commercial Companies. From the earliest times, the commercial enterprise of the Europeans has been directed towards an immediate intercourse with the East Indies; but the Arabian empire, and its mercantile grandeur, at first, and the dominions of the Persians and Turks at a later period, presented insurmountable barriers. The commercial shrewdness of the Italian republics did not succeed in entirely overcoming these obstacles; and even the Venetian commerce with India, extensive as it was, could not be called direct.

After the Turks had established themselves in Europe, by the conquest of Constantinople, and in Africa, by that of Egypt, the access to India was more completely shut up, and the enterprising spirit of the merchants of Christendom was turned to the discovery of a direct channel to that land of commerce. The west of Europe was delivered from the Saracens, and the warlike spirit which had long been occupied by the contests with the infidels, required some new scene of activity. The great Portuguese prince Henry, surnamed the *Navigator*, first directed this energy towards the eastern ocean; and not half a century had elapsed from the taking of Constantinople, when Vasco de Gama (1498) landed in Hindostan, on the coast of Malabar, and the Portuguese successfully established themselves on those distant shores. The whole commerce of the East Indies was in their hands for nearly a century—the golden age of Portugal. The efforts of Alphonso Albuquerque, Nuno da Cunha and Francis Xavier—the latter with spiritual weapons, and the former by force of arms—will ever be remembered with admiration, even had they not been sung in the verses of Camoens. During eighty years, while the transportation of Indian productions through Genoa, Venice, and the Hanse Towns, was constantly diminishing, Lisbon was the India of the north of Europe.

The English and Dutch obtained their supplies of Indian spices either from Lisbon or from Portuguese merchants in Antwerp. Venice also found herself supplanted by the military power of the Portuguese, and the subjection of her commercial friends, the Saracens. When, however, Philip II., in 1580, united Portugal with the Spanish Monarchy, and soon after commenced his war with England, against whose vessels he closed the ports of his empire, the British merchants were compelled to draw their supplies of Indian produce from the Netherlands. The Dutch took advantage of this circumstance, and raised the price of pepper to three times its former amount. But the revolt of the Netherlands from Spain induced Philip II. to take decided measures against the Dutch commerce also, and the capture of their vessels in the port of Lisbon compelled the Dutch to engage in a direct trade to India: the English soon followed their example. Thus, during the last ten years of the sixteenth century, the foundation was laid in England and Holland, nearly at the same time, of those great commercial corporations, called *East India Companies.* They are distinguished from the Hanseatic league, and other earlier unions of that kind, in being merely associations of individuals uniting for a common commercial purpose, with transferable shares, and not of political bodies; and also by having bought their privileges and rights at once from their own governments, while those of the earlier commercial confederacies were obtained, together with their political privileges, by successive treaties.

As such an extensive commerce in distant parts of the world requires a political power to preserve and protect it, we find our own countrymen, the Dutch, and other smaller East India companies, engaged, soon after their establishment, in labouring to form a political power on the basis of wealth; which, even if it succeeded, would not accord with the politics of the mother country, and would not be able, for any great length of time, to resist the reaction that would arise in the conquered countries. I. The earliest India company was the Portuguese, although essentially different, in its organization, from the others. By the union of Portugal with Spain, the connection between the distant Portuguese governments in India and the mother country became less close. Abuses of every kind, illicit traffic on the part of the viceroys and officers, smuggling, and piracy, became prevalent. The Spanish government perceived that the East India commerce, if continued on account of the crown, would not only be unprofitable, but would occasion an annually increasing loss, and therefore granted the exclusive privilege of the East India trade, in 1587, to a company of Portuguese merchants, in consideration of the annual payment of a considerable sum.

This company, in attempting to enforce its privileges, became involved in disputes, equally disadvantageous to both parties, with the Portuguese government in India, which was engaged in the smuggling trade; and the way for the enterprises of the Dutch and English could not have been better prepared than by this weakening of the Portuguese power. To this may be added the impatience of the Indian nations under the Portuguese yoke, and the jealousy and hatred entertained against both by the Arabians.

The English and Dutch companies found every thing in that state of division which is favourable to the establishment of a third party, by means which, in any other case, would be entirely inadequate. This explains their immediate and brilliant success, notwithstanding the great inferiority of their strength. The Portuguese company, on the contrary, on the breaking out of open war between England and Holland and Spain, soon became unable to pay the annual tribute to the crown, and gradually declined, till, in 1640, on the re-establishment of Portuguese independence by King John IV., of the house of Braganza, it was entirely abolished.—From that time the insignificant remains of the Portuguese commerce with the East Indies have been in the hands of the government, if we except the unsuccessful attempt to form a new company in 1731.

II. Eight years after the establishment of the first Portuguese company, the offer of a Dutchman, Cornelius Houtman, who had been taken prisoner by the Spanish, and had become acquainted with the Portuguese East India trade, induced the merchants of Amsterdam, who had already made three unsuccessful attempts to discover a passage to India through the Northern Ocean, to form a company, under the name of the *Company of Remote Parts,* and send their first commercial fleet round the Cape of Good Hope to India, under the command of Houtman. Four small vessels were equipped with a capital of 70,000 guilders, and sailed the 2nd of April, 1595, from the Texel. The example of Amsterdam was followed in the other United Provinces; but these companies soon became aware that they interfered mutually with each other; and March 20th, 1602, they were united by a charter from the States General, conferring on them the exclusive privilege of trading to the East Indies for twenty-one years, together with all necessary civil and military powers. The former companies remained, in some measure, distinct from each other, and the six cities of Amsterdam, Middleburg, Delft, Rotterdam, Horn, and Enkhuysen, which had made the first attempts, were allowed to continue the commerce from their ports. This company began its operations with a capital of 6½ millions of guilders; 65 directors—divided amongst the different members, in proportion to the amount of shares, so that Amsterdam had twenty-five, Middleburg twelve, and each of the other cities seven—superintended the equipment of the vessels in their respective ports; a committee of fifteen directors, apportioned in the same manner, had the general direction of affairs.

In 1622, the subject of the renewal of the charter being before the States General, it appeared that, during the twenty years of its existence, thirty millions of guilders (that is, more than four times the amount of the original capital) had been divided amongst the stockholders; besides which, a great amount of capital had been vested in colonies, fortifications, vessels, and other property, on which no dividend could be made. These results will not be surprising if we consider how much more favourable was the condition of the East Indies, in every respect, for re-republicans and Protestants than for Catholics and subjects of a monarchy.

The Portuguese acted on the principle, that without a strong military force, and a religion common to the conquered and ruling nation, no permanent commercial connection could be formed; and this system was pursued for a century, sometimes with prudence, but more frequently with great inhumanity. The Dutch, on the contrary, with their indifference to the moral relations of nations, and their

well-conducted commerce, were well calculated to succeed. Their superiority to the English, in their first enterprises, was owing not only to their superior skill by sea, their youthful republican spirit, and the greater amount of their capital, but chiefly to their having carried on all their operations, from the first, with a common capital, while our East India Company, till 1610, was a mere association, each member of which transacted business on his own account, merely conforming to certain general rules, such as the employing the Company's ships.

It has been proved by subsequent results, that a mere money power cannot be upheld without an entire disregard of the claims of humanity; and the example of the first Portuguese conquerors has convinced enlightened men, that the dominion of Europeans in India remains insecure, if not founded on a certain moral, legal, and religious community with the inhabitants of the country. The charter of the Dutch East India Company was continued till 1644; Batavia was founded in a very favourable situation for the traffic with the Spice Islands, the chief branch of the Indian trade; 34—41 freighted vessels annually left the ports of Holland for India; 25—34 merchant vessels, on the average, returned.

The commerce with Japan increased rapidly, and the extension of Portuguese power in the Brazils, after the accession of the house of Braganza to the throne, although a great disadvantage to the Dutch West India Company, promoted the interest of the East India Company, by directing the attention of the Portuguese wholly to America, and leaving free scope to the Dutch in Asia. In 1641, Malacca, the capital of the Portuguese East Indies, fell into the hands of the Dutch, by the treason of the governor.—But the increasing activity of the English and French, and the political and military establishments of the Company, diminished their profits, and it was difficult to raise the 1,600,000 of guilders, which were to be paid to the States General, in 1644, for the extention of the charter till 1665. Soon after, however, the independence of the republic of the United Provinces was secured by the peace of Westphalia—an event which was of great advantage to the Company, and enabled them to found colonies on the Cape of Good Hope.—This was done in the course of 20 years (from 1650), at an expense of 20 millions of guilders. These colonies were a great assistance to the intercourse between Europe and India, and richly repaid the expenses incurred.

In 1658 the conquest of Ceylon was completed, after a vigorous defence by the Portuguese; and the Tartar revolution in China occasioned the settlement of 30,000 Chinese, who would not submit to the new government, in the Dutch island of Formosa. These proved a valuable accession to the population. Although the direct commerce with China had to struggle with insurmountable difficulties, the indirect communication through these emigrants, who were well acquainted with the country, and the influx of Chinese productions from all sides into Batavia, amply recompensed the Company. They were, however, deprived of this valuable island in 1661, by a Chinese adventurer, named Kaxinga, whose family afterwards ceded it to the Emperor of China.

The energy of the Company seemed to be excited by this loss. In 1663, the most valuable settlements of the Portuguese on the coast of Malabar were taken; and, in 1666, by the conquest of Macassar, the object of the exertions of 70 years, they obtained the monopoly of the spice trade. At this time the civil and military expenses of the Company, exclusive of the expenses of the war, amounted to 3½ millions of guilders.

In 1665, after much opposition, the charter was renewed till 1700, on condition of the payment of a large sum into the treasury; and the report of the Company showed an almost inconceivable extention of commerce.—Their factories extended from the Cape of Good Hope to the coasts of Arabia and Persia. They were masters of all the important settlements of the Portuguese, from Surat, on the Malabar coast Ceylon, with its cinnamon and ivory; the pearl fishery and cotton trade on the coast of Coromandel; Bengal and Orissa, with their silks and cottons, rice, sugar, saltpetre, &c., were in the hands of the Company, as was also the commerce with Pegu, Siam, and Tonquin, only interrupted by some temporary accidents. They obtained valuable supplies of silver and copper from Japan, carried on an extensive trade in spices with Amboyna, the Banda Islands, and the Moluccas, &c. Malacca, the principal seat of the Portuguese trade, appeared, by this report, to be on the decline, the expense of protection being disproportioned to the size of the place; and the Straits of Sunda, on which Batavia is situated, had superseded the Straits of Malacca, as the general passage to the more distant parts of the East.

The charter of the Company has since been several times renewed, and always on condition of the payment of large sums; from 1701—40; then till 1775; and in 1776 for 30 years more, for the sum of two millions of guilders, and the annual payment of 360,000 guilders.

Avarice and cruelty, which increased with the gradual decay of the republican spirit, and the decline of simple and moderate habits; a shameless system of intrigue towards their allies, and particularly their incapacity to appreciate the moral and religious character of the nations of India; and, finally, the renewed vigour of the British Company at the commencement of the 18th century, and the change in the European demand; the preference given to other spices;—these are the principal causes of the decline of the Dutch East India Company. In the 18th century, their annals abound with relations of conspiracies, insurrections, and generally unsuccessful wars; and, in 1781, we find them so completely broken up by the war with England, and by enormous political expenses, that the States General, notwithstanding their own difficulties, were obliged to assist them with a loan.

In the first revolutionary war, the Company lost most of their possessions, and were obliged to suspend the payment of their dividends in 1796. They had scarcely taken possession of what was restored to them by the peace of Amiens, 1802 (this country retaining only Ceylon), when every thing was lost by the new war; and at the general peace they retained none of their early East India possessions but the governments of Batavia and Amboyna, Banda, Ternate, Malacca, Macassar, and some scattered factories on the coasts of Malabar and Coromandel. The Cape of Good Hope and Ceylon were lost to them for ever. At their commencement, the Dutch East India Company had enjoyed the advantage of all the Portuguese establishments; their forts, magazines,

artillery, and provisions for defence, their commercial and political relations, and an immense booty which the capture of the Portuguese ships on every sea afforded them; while, on the contrary, the English had to struggle for a century with the difficulty of gradually gaining the ground on which to plant their commercial lever. But the very circumstance of their slow progress gave a firmer footing to their power.

III. The history of our own East India Company may be divided into four periods. During the first fourteen years, its members were, in a great measure, independent. In the following ninety-five years, although it had a common capital, its operations were confined by the superiority of the Dutch in the Indian seas, by the civil wars at home, and particularly by the calling in question of its exclusive privileges, which were merely a royal, and not a parliamentary grant. For the succeeding forty years, it enjoyed all its rights undisputed, and founded on parliamentary authority, but confined to mere commercial transactions. And, finally, during the subsequent seventy years, its political power was developed.

1. Period from 1600 to 1613. Our countrymen, in their first attempts to reach India, directed their course to the north-west, as the Dutch did to the north-east. John Cabot, in the employ of Henry VII., had discovered Newfoundland, and the coasts of North America, in 1497. In 1553, his son, Sebastian Cabot, under Edward VI., engaged in a second enterprise of this kind. The king chartered a company, which, with a capital of 6000*l.* equipped three vessels, for the discovery of a northern passage to India. Part of this expedition was lost in the Northern Ocean; another part landed on the northern coast of Russia, and formed commercial connections which gave rise to the English Russian Company, in the same manner as the Hudson's Bay Company owes its establishment to the attempts to discover a north-west passage, which have been continued to the present day. The British, at the same time, endeavoured to penetrate to India, directly, by land, and, at least, to rival the Venetians, if they could not contend with the Portuguese. This was the main object of the Turkish Company, established in 1581, which, however, soon became convinced of the impracticability of the attempt, and was induced, by Sir Francis Drake's account of his circumnavigation (1591), to send out three ships to India, under the command of Captain Raymond, on the route of the Portuguese. This attempt, and that made by Robert Dudley, in 1596, failed entirely.

The Spanish war, the shutting up of Lisbon, and the avarice of the Dutch, gave, however, a new vigour to the enterprise of the London merchants, and, Sept. 22, 1599, a society was formed in London, which, in the course of rather more than two centuries, has acquired the greatest power of any commercial association on record. The original capital amounted to 30,133*l.* sterling; and Queen Elizabeth, Dec. 31, 1600, granted to the Governor and Company of Merchants of London trading to the East Indies, for fifteen years, the exclusive right of trading to all countries from the Cape of Good Hope eastward, to the Straits of Magellan, excepting those which were in the possession of friendly European powers.

Until 1613, the Company consisted merely of a society subject to particular regulations; each member managed his affairs on his own account, and was only bound to conform to certain general rules. Notwithstanding the disadvantages of this arrangement, the profits of eight voyages amounted to 171 per cent.

2. Period from 1613 to 1708. At this time (1613), the capital was united, and the constitution, in consequence, became more aristocratic; the largest stockholders having the principal management, and the great mass of the stockholders having only a nominal control in the general meetings. These latter, in reality, had only in view speculation in the shares. The concerns of the Company were so prosperous, that, in the course of four years, the shares rose to the value of 203 per cent., and the Dutch became desirous, though they did not succeed, to unite with it against the Portuguese. Its factories were extended to Java, Sumatra, Borneo, the Banda Islands, Celebes, Malacca, Siam, the coasts of Malabar and Coromandel, but chiefly to the states of the Mogul, whose favour the Company had very prudently secured. Their success was such, that, a new subscription being opened in 1616, the amount raised was 1,629,040*l.* But, in 1627, complaints were made of bad management, and abuses of all kinds, particularly in regard to the private commerce of the officers, which has always been of the greatest disadvantage to all such companies.

The opposition to the royal authority under the Stuarts, brought into question the monopoly of the Company which rested on a royal grant. The kings themselves contributed to raise these doubts, by granting to individuals the privilege of trading to India, much to the disadvantage of the Company. During the time of the Commonwealth, the public opinion became very strong against monopolies, and Cromwell, by destroying the charter, in 1655, attempted to make the East India trade free. But this was impracticable. To give up the Company, was to destroy the whole basis of power and influence obtained in India. After the restoration of the royal family, the charter which even Cromwell had been obliged to renew, was again in full force.

During the short period which elapsed from this time to the revolution of 1688, the Company obtained, by the acquisition of Madras and Bombay, the predominance on the coasts of Malabar and Coromandel, and laid the foundation for the extension of its possessions into the interior of Hindostan, and for that power which rose on the ruins of the empire of the great Mogul. The affairs of the Company were not, however, in a prosperous state; and, soon after the revolution, the question was started, whether the King could impose restrictions on commerce by a charter, and whether a sovereign, who possessed the rights of sovereignty conditionally, could confer them on a privileged company. The consequence was, that, the Company not being able to perform their obligations, on account of the losses occasioned by wars, infidelity of officers, extravagance, &c., Parliament granted a charter to a new East India Company, in 1698, on condition of a loan of 2,000,000*l.* sterling, at 3 per cent., for the service of the state. But the great contentions between the two companies soon made it necessary to unite them, and a union was effected in 1708.

3. Period from 1708 to 1748. In 1708, an act of parliament was passed, establishing the English East

India Company on its present footing, under the title of The United Company of Merchants of England trading to the East Indies. Its exclusive privileges were granted till 1726, after which it was determinable upon three years' notice. The capital was raised by the sale of the shares: one share (of the value of 500*l.*) gave the holder a vote in the "General Court;" four shares, or stock to the amount of 2000*l.*, rendered the holder eligible as one of the twenty-four "directors," who managed the government of the Company. The shares being transferrible, the great mass of stockholders are constantly changing, and take no personal interest in the affairs of the Company, but merely speculate in the shares. The wnole management is left exclusively in the hands ot the directors, and all the numberless abuses of an oligarchical constitution are readily introduced.

The local affairs of the Company were intrusted to the three councils of Madras, Bombay, and Calcutta, while the general direction was retained in England. But, as every thing depended ultimately on the local officers in India, the pernicious abuse prevailed of attempting to secure the fidelity of the superior officers, by allowing them to appropriate to themselves the inferior lucrative posts. The renewal of the charter in 1732 was not obtained without great difficulty, and against a powerful opposition. The Company therefore thought it adviseable, in 1744, to advance 1,000,000*l.* sterling, at 3 per cent., for the service of government, in consideration of an extension of their grant till 1780.

4th Period. The political power of the English in India commenced in 1748. The French had already set the example. In 1746, a French battalion had destroyed the army of the Nabob of the Carnatic, and, soon after, the French officers succeeded in disciplining Indian troops according to the European method. The inferiority of the native Indian troops opposed to European soldiers, and the facility of instructing Indian soldiers, known by the name of *Sepoys*, in the European discipline, was thus proved. Ambition and avarice, political and mercantile cunning, could now act on a larger scale; and the independence of the Indian princes was gone whenever this trading company, which was already encroaching upon all the rights, both of the rulers and the people of those countries, should establish a permanent military force. Thus far, the military organization of the Company had been merely on the defensive: it now became able to act offensively; and the entire difference of the European and Indian notions of law could never fail to furnish opportunities to put this new means of power into action.

The rights of succession, and all the rights of princes, subjects, and families, were so much disputed on the different principles of the Indian, Mohammedan, and British laws, that the Company (which often interposed as arbitrator) easily succeeded in extending their legal jurisdiction. If called to account in Europe for any of its undertakings, it was easy to uphold the correctness of its conduct, politically, on the ground of self-defence, which, at the distance of several thousand miles, could not be called in question; and, in legal matters, by taking advantage of the impenetrable labyrinth of law. Edmund Burke, who experienced, in the case of Hastings, this impregnability of the Company, accused them justly "*of having sold every monarch, prince, and state in India, broken every contract, and ruined every prince and every state who had trusted them.*"

The high officers in India, whatever great names may appear among them, become despotic from situation: 1. because each receives an inheritance of injustice, which must be maintained; 2. because public opinion has no influence; 3. because no moral and religious connection, nor even that of language, exist between the ruled and the rulers; 4. because no fear of dangerous insurrections can exist, on account of the great division of the Hindoo and Mohammedan classes and interests; 5. because the officers of the Company have no object but to make money, with a view of spending it in England, as soon as they have accumulated sufficient to satisfy their wishes, and, therefore, are not disposed to make opposition against abuses.

In 1749, the robberies of the Company began with its protection of the pretender of Tanjore. Under pretence of illegitimacy, the nabob of this district was driven out, for the purpose of obtaining some cessions of territory, and then restored, on making farther concessions. The rapid progress of the Company in the art of extending their possessions, appears from their treaties with Surrajah-Dowlah, the Nabob of Bengal, in 1757, when large and rich provinces were the reward of their faithless policy. This enlargement of territory caused such enormous expenditures, the difficulties of governing increased so greatly with the increase of power, the numerous officers became so much more independent, rapacious, and disobedient, that the finances of the Company suffered.

The direction in London was now nothing more than a mere control of the real government, which had its seat in India. Its orders were antiquated before they reached Calcutta. The governors having the advantage of being on the spot, it was to be expected that they would obey only when personal interest required it. Thus the repeated prohibition to carry on a traffic in the interior, with salt, tobacco, and betel nuts, was entirely disregarded, with the express consent of the East Indian councils; and, long after the directors had forbidden the officers of the Company to accept presents from the Indian princes, it was proved that they had openly received them, to the amount of 6,000,000*l.* from the family of the Nabob of Bengal alone. On this account, the internal situation of the Company became constantly worse, and, in 1772, it was compelled to raise a loan, at first of 600,000*l.*, from the Bank, and afterwards of 1,400,000 from the Government, for its current expenses. The public dissatisfaction was the greater, as it had been expected that the extension of British power in India would have brought much wealth into the mother country. At the same time, great complaints were made against the unprincipled conduct of the Company's officers towards the princes and people of India; and, as the expected advantages appeared not to have been obtained, it now began to be proclaimed, that the rights of humanity had been trampled upon.

The popular hatred was unjustly directed against the directors; their power was to be limited; they, who had to manage a disobedient world, were to be still more cramped. Control was demanded; as if a control which sympathises with the oppressors, and has no connection with the oppressed, could avail any thing; as if oppression were a single act, which

might be prevented by superintendence, or punished like a crime: and what would be the effect of a controlling power whose commands would require more than half a year to be conveyed to the spot, and as much more time before the result could be known in Europe? And, if the Company had obtained a power by force, which could only be preserved by the same means, on what principle should the control act?—Burke's famous, but unsuccessful struggle of seven years, against Hastings, and in the cause of humanity in India, proved that the only possible control of the officers in India, is the public opinion of the British nation. One party asserted that all would be well as soon as the Company divided its power with the ministry. Another party maintained that all that was wanting to the Hindoo was the benefit of British law.

Some thought it would be sufficient merely to increase the difficulty of becoming a director. Thus the incomplete reform of 1773 took place. Instead of 500*l.*, 1000*l.* was made necessary to give the right of a vote, 3000*l.* for two votes, 6000*l.* for three votes, and 10,000*l.* for four votes. Only six directors were to be annually elected. A governor-general, with four counsellors (at first named by Parliament, that is, by the ministry, but afterwards by the directors, for five years), was to be placed over the provinces of Bengal, Bahar, and Orissa; the other provinces were to be dependent upon him.

As a counterpoise to this concentration of power, a supreme court was established at Calcutta, with a chief justice and three associate judges, who were independent of the Company, and were appointed by the crown. All the civil and military correspondence of the Company was to be communicated to the ministry. Under the old system, in many disputed cases, conscience, or, at least, common sense, had decided; but now, the introduction of a new and strange legal constitution occasioned the ruin of all legal relations. The court decided in the case of every complaint made against any individual who was directly or indirectly in the service of the Company, as well as all complaints relating to contracts in which the parties had submitted to its jurisdiction.

If we consider that nothing was more uncertain than the personal condition of the Indian and Mohammedan inhabitants of Hindostan; that the Company governed some provinces immediately, others indirectly, by means of nabobs; that the zemindars were sometimes considered as the independent nobility of India, sometimes as officers of the Company, &c.—it follows, that the court could take all cases into its own hands, or decline them at pleasure. Immediately after its establishment, it gave a specimen of the spirit by which it was actuated. Nunkomar, who had accused the governor-general, Hastings, was convicted, on insufficient grounds, of forgery, and hanged. On the whole, the history of the British East India trade justifies the assertion that, except Burke, and the family of Wellesley, scarcely a single Englishman has ever entered completely into the spirit of the people of India. When the inefficacy of the measures of 1773 was sufficiently proved, and the finances of the Company again suffered by the American war, the establishment of a board of control was again discussed in Parliament, and on broader grounds; from 1782 to 1784, the greatest men of England were engaged on this important subject. The famous East India bill of Fox, which proposed seven commissioners, to be appointed by Parliament, and invested with supreme power, and, as it were, the right of protection over India, could not be agreeable to the court, as the principal object of the bill was to deprive the crown of all influence on Indian affairs, and to place an intermediate power between the king and India. Pitt's project, therefore, took effect.

A *board of control* was erected, dependent on the crown, authorized to superintend the civil and military government and the revenues of the Company, and to transmit the dispatches of the directors to the different presidencies. The salaries of the governor-general, the president, and the council were fixed by the king.

We have thus given a historical outline of the constitution of the Company. The power of control in England, so far as any exists, is in the hands of the ministry; the particular direction of the government is subjected to the Company. It is certain that, since the establishment of the board, much less is known of Indian affairs than formerly. The ministers have not the same grounds for occasional investigation; the stockholders, in the general meetings of the Company, can effect nothing, even if desirous to interfere, while the board and the directors agree; and this agreement is the more firmly established, as a committee of secrecy exists, consisting of three directors, which can consult and decide, with the concurrence of the board, without any communication with the other directors. The improvement of the moral condition of British India is impossible, while the fear of a result like that which occurred in the case of the North American colonies, prevents the regular colonization and establishment of British subjects in India. A race of Englishmen born in India could alone succeed, in the course of time, in bringing order and harmony into the jarring interests and relations of the country. The political importance of the East Indies, in their present state, to England, is too great to allow us to expect any immediate improvement in the condition of India.

A taxable population of 83,000,000 of inhabitants, with 40,000,000 under dependent native princes; an army of 200,000 men, in the service of the Company; about 16,000 civil officers; an annual export of about 14,000,000*l.*, and an import to the same amount, from all parts of the world, are objects which outweigh all moral considerations. This gigantic political-mercantile association might exist as long as a small military power is sufficient to prevent a great nation from attempting to throw off the yoke; as long as the system *de faire le commerce en sultan et de faire la guerre en marchand* can survive; as long as the pretensions of the *metis*, the offspring of European fathers and Indian mothers, do not increase; and the Indians and Mohammedans remain ignorant of the real weakness of their oppressors; that is, as long as the course of nature is reversed. Since 1813, all British subjects have been permitted to trade to the East Indies, under certain conditions advantageous to the Company, which has, however, claimed the exclusive commerce in tea. It appears that the revenue of the British possessions in India is greater than that of any European state, excepting France and England. In 1827-28, it amounted to 23,035,164*l.* in 1828-29, it is estimated at 23,350,317*l.* The interest on the debt is about 2,000,000*l.* yearly; the

total interest on the debt and charges, including those paid in England, and the expenses of the island of St. Helena, was 26,314,344*l.* in 1827-28, and 23,994,503*l.* in 1828-29; the surplus of charge above revenue was, in 1825-26, over three millions; the estimated surplus revenue in 1829, 1,318,593*l.* Before the Burmese war, there was a surplus of revenue over expenditure of one million and a half; but in the twenty years preceding 1828-29, there are only six which show a surplus revenue. The total assets of the Company, including property of every description, amounted to 18,406,039*l.* The rate of dividend, since 1793, has been 10½ per cent. It is believed that the value of American imports from England into China amounts to 800,000 dollars, whilst that of the Company amounts to 800,000*l.* The Company's tonnage to China had increased, for the last nine or ten years 5000 on an average.

The present value of the trade possessed by the British East India Company, with reference to the private trade, will be best understood by reference to a document printed by order of the House of Commons.

Between India and China, we find a total of 4,229,354*l.* sterling, for one year. This includes both imports and exports, out of which the Company have but 433,388*l.*, and the remainder belongs to private individuals. The exports and imports, between England and China, on account of the Company is rather less than two millions and a half pounds sterling.

The amount of the population of the British East Indies cannot, of course, be known with any thing like accuracy; but the following is probably as near an approximation as can be made:—In the Bengal presidency, 58,000,000; Madras presidency, 16,000,000; Bombay presidency, 11,000,000; total British, 85,000,000; subsidiary and dependent (say), 40,000,000; outports in the bay, &c. (say), 1,000,000; total under British control, 126,000,000; independent states, but controlled by the British arms (say), 10,000,000; approximate total, not European, 136,000,000; total Europeans, about 40,000; about one European to three thousand four hundred natives, or, where they have the whole command of the government and revenue, one European to two thousand one hundred and twenty-five natives.

As the charter of the East India Company is about to expire, no doubt every effort will be made by their friends to ensure its renewal, and it is most probable that they will effect their object; but common sense should teach those who legislate for the commercial interests of this country, not to continue the whole of those oppressive regulations which now shackle our trade with so large a portion of the globe. The morality of the question, as to whether we should keep a mighty empire in darkness merely because they would break the bonds which now fetter them the moment they became intellectually enlightened, requires but little discussion. The political power of the Company appears rather beneficial than otherwise to the natives, but they must be taught to wield it with a different spirit. A free press, the only basis of free institutions, must be established, and the natives of this country must be allowed to settle in the Company's territories, as they do in any other colonies belonging to Great Britain, without the Indian government having the power, as in the case of Mr. Buckingham, to issue a species of *lettre de cachet*, for their seizure and removal.

Since writing the above, we find that the charter is likely to be renewed, but in a modified form. Colonization is to be permitted, though without allowing a free trade with the interior, and the China trade is to be thrown entirely open.

IV. The French, Danish, and Swedish East India companies have been of little importance, even in their most flourishing state, to the commerce of the world. The French, established in 1664, could not succeed; in 1796, the trade was again thrown open. A new company established in 1785, expired in 1791. The East India company in Denmark established in 1618, and several times renewed, finally surrendered its possessions to the king in 1777. The company has now only the Chinese trade. The Swedish East India Company established in 1731, and renewed in 1766 and 1786, still exists at Gottenburg. For every voyage it pays 75,000 dollars in silver to the crown, to which, on its establishment, it was obliged to advance 3,000,000 dollars in silver, of which one million, not on interest, is merely a security, and the other two millions are considered as a loan.

East India Fly (*lytta gygas*). This species of cantharides has been tried in America; and they were found to be exceedingly active as vesicatories, and never failed in their effect. They produce a vesication, in general, much earlier than the Spanish fly, and, from being found so much more active, only one half the quantity is added in making the *emplastrum cantharidis*.

Eau de Cologne, or water of Cologne, a fragrant water, made originally, and in most perfection, in Cologne. Formerly many wonderful powers were ascribed to this water, but it was probably never so much in demand as at present, in Europe and America, and numberless recipes have been given for its manufacture. It was invented by a person named *Farina*, in whose family the secret, as they say, continues to be preserved, since chemistry has not been able as yet to give the analysis of it. It is imitated, however, everywhere. The consumption of this perfume has increased, and there exist at present, fifteen manufactories of it in Cologne, which produce several millions of bottles yearly; much, also, is manufactured at Paris, in Saxony, and other places. One of the many recipes to make *eau de Cologne* is the following:

Alcohol, or spirit of wine, at 30° . . 2 pints.
Oleum neroli*
——— de cedro
——— de cedrat
——— cort aurant } . . . . 24 drops.
— citri
——— bergamot
——— rosmarin
Seed of small cardamum . . . . 2 drachms.

Distil it in a sand-bath, until three-fourths of the alcohol have evaporated.

Eau de Luce (*aqua Lucia*, or *spiritus salis ammoniaci succinatus*); invented by a person named *Luce*, at Lille, in Flanders; a volatile preparation, thus made: ten or twelve grains of white soap are dissolved in four ounces of rectified spirit of wine, after which the solution is strained, and a drachm of rectified oil of amber is added, and the whole is filtrated. Afterwards, some strong volatile spirit of sal ammonia should be mixed with the solution.

* Ethereal oil of orange-flowers.

Eaves; the edges of the roof which overhang a house.

Ebb; the reflux of the tide toward the sea.

Ebony; a kind of wood, extremely hard, and susceptible of a very fine polish, which is much used in mosaic, inlaying, and other ornamental works. Its colour is red, black, or green. The black is most esteemed, and is imported principally from Madagascar and the Isle of France. *Red ebony*, so called, though its colour is brown, striped with black, is less compact, and is also brought from Madagascar. The green is softer than either of the preceding, yields a fine green tincture, which is employed in dyeing, and is brought from the West Indies, particularly from Tobago, as well as from the above-mentioned islands. The best is jet black, and free from knots, or reddish veins. Ebony is imitated by subjecting some hard kinds of wood, especially that of the pear tree, to a hot decoction of galls, and, when this is dry, applying ink with a stiff brush; a little warm wax is then used to give it a polish: another method is, by heating and burning the wood.

Ebullition; the act of boiling up with heat; any intestine violent motion of the parts of a fluid. In water, under ordinary circumstances the phenomena of ebullition do not take place till the fluid arrives at 212°.

Eccentricity *of the planets*; the distance between the sun and the centre of the orbit in which the planet moves.

Ecchymosis, in *surgery*. This term signifies a livid or blue discoloration of the skin, caused by the rupture of vessels, and extravasation of blood. Contusions are always attended with a degree of ecchymosis.

Echelon (*French*; a ladder or stairway); used in military language. A battalion, regiment, &c., marches *en échelon*, or *par échelon*, if the divisions of which it is composed do not march in one line, but on parallel lines. The divisions are not exactly behind each other, but each is to the right or left of the one preceding, so as to give the whole the appearance of a stairway. This order is used if the commander wishes to bring one part of a mass sooner into action, and to reserve the other. If the divisions of the *échelon* are battalions, these are generally from 100 to 200 steps from each other.

Echo. When the waves of sound strike against a distant, hard surface, they are reflected, and heard again after a short space; this repetition is called *echo*. If the sound is repeated several times, which is the case when it strikes against objects at different distances, many echoes are heard. This phenomenon is not caused by a mere repulsion of the sonorous particles of air, for then every hard surface would produce an echo; but it probably requires a degree of concavity in the repelling body, which collects several diverging lines of sound, and concentrates them in the place where the echo is audible, or, at least, reflects them in parallel lines, without weakening the sound, as a concave mirror collects in a focus the diverging rays of light, or sometimes sends them back parallel.—Still, however, the theory of the repulsion of sound is not distinctly settled, probably because the nature of reflecting surfaces is not sufficiently known. The reflecting surface must be at a certain distance, in order that the echo may come to the ear after the sound, and be yet distinctly separated from it. (See Acoustics.)

Echo, in *music*; the repetition of some part of an air in a very low, soft, manner, in imitation of a real echo.

Echometer, in *music*; a kind of scale or rule, with several lines thereon, serving to measure the duration and length of sounds, and to find their intervals and ratios.

Eclipsareon, in *astronomy*; an instrument invented by Mr. Ferguson for exhibiting the duration and character of eclipses.

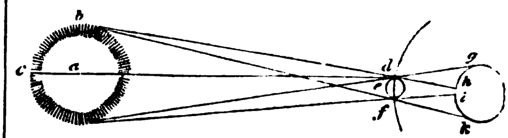
Eclipse. *An Eclipse of the Moon* is a privation of the light of the moon, occasioned by an interposition of the earth between the sun and the moon; consequently, all eclipses of the moon happen at full moon; for it is only when the moon is in opposition, that it can come within the earth's shadow, which must always be on that side of the earth which is from the sun. The earth being in the plane of the ecliptic, the centre of its shadow is always in that plane: if, therefore, the moon be in its nodes, that is, in the plane of the ecliptic, the shadow of the earth will fall upon it. This shadow, being of considerable breadth, is partly above and partly below the plane of the ecliptic; if, therefore, the moon in opposition be so near one of its nodes that its latitude is less than half the breadth of the shadow, it will be eclipsed. But, because the plane of the moon's orbit makes an angle of more than five degrees with the plane of the ecliptic, it will frequently have too much latitude at its opposition to allow it to come within the shadow of the earth.

An Eclipse of the Sun is an occultation of part of the face of the sun, occasioned by an interposition of the moon between the earth and the sun; thus all eclipses of the sun happen at the time of new moon. The dark or central part of the moon's shadow, where the sun's rays are wholly intercepted, is called the *umbra*, and the light part, where only a part of them are intercepted, is called the *penumbra*; and it is evident that, if a spectator be situated on that part of the earth where the umbra falls, there will be a total eclipse of the sun at that place; in the penumbra there will be a partial eclipse, and beyond the penumbra there will be no eclipse. As the earth is not always at the same distance from the moon, if an eclipse should happen when the earth is so far from the moon that the rays of light proceeding from the upper and lower limbs of the sun cross each other before they come to the earth, a spectator situated on the earth, in a direct line between the centres of the sun and moon, would see a ring of light round the dark body of the moon; such an eclipse, as we stated in the article Astronomy, is called *annular*. People situated in the penumbra will then perceive a partial eclipse; and an eclipse can never be annular longer than 12 minutes 24 seconds, nor total longer than 7 minutes 58 seconds; nor can the duration of an eclipse of the sun ever exceed 2 hours.

The sun being larger than the earth, the earth's shadow is a cone, whose base is on the surface of the earth, and the moon is eclipsed by a section of the earth's shadow. If the earth were larger than, or equal to, the sun, its shadow would either perpetually enlarge, or be always of the same dimension; but, in this case, the superior planets would sometimes come within it, and be eclipsed, which never happens. Therefore the sun is larger than the earth, and produces a shadow from the earth of a conical form, which does not extend to the orbit of Mars. An

eclipse of the moon is *partial* when only a part of its disc is within the shadow of the earth; it is *total* when all its disc is within the shadow; and it is *central* when the centre of the earth's shadow falls upon the centre of the moon's disc. Now the nearer any part of the penumbra is to the umbra, the less light it receives from the sun; and, as the moon enters the penumbra before she enters the umbra, she gradually loses her light, and appears less brilliant. The duration of an eclipse of the moon, from her first touching the earth's penumbra to her leaving it, does not exceed five hours and a half. The moon does not continue in the earth's umbra longer than three hours and three quarters in any eclipse, neither is she totally eclipsed for a longer period than one hour and three quarters. As the moon is actually deprived of her light during an eclipse, every inhabitant upon the face of the earth who sees the moon sees the eclipse. An eclipse of the sun, as we have said, happens when the moon, passing between the sun and the earth, intercepts the sun's light; and the sun can only be eclipsed at the new moon, or when the moon, at its conjunction, is in or near one of its nodes. For, unless the moon is in or near one of its nodes, it cannot appear in or near the same plane with the sun, without which it cannot appear to us to pass over the disc of the sun. At every other part of its orbit, it will have so much northern or southern latitude as to appear above or below the sun. If the moon be *in* one of its nodes, having no altitude, it will cover the whole disc of the sun, and produce a total eclipse, except when its apparent diameter is less than that of the sun; if it be *near* one of its nodes, having a small degree of latitude, it will only pass over a part of the sun's disc, or produce a partial eclipse. In a total eclipse of the sun, the shadow or umbra of the moon falls upon that part of the earth where the eclipse is seen, and a spectator, placed in the shadow, will not see any part of the sun, because the moon will intercept all the rays of light coming directly from the sun. In a partial eclipse of the sun, a penumbra, or imperfect shadow, of the moon, falls upon that part of the earth where the partial eclipse is seen. Were the orbit of the earth and that of the moon both in the same plane, there would be an eclipse of the sun every new moon, and an eclipse of the moon every full moon. But the orbit of the moon makes an angle of five degrees and a quarter with the plane of the earth's orbit, and crosses it in two points, called the *nodes*. Astronomers have calculated that if the moon be less than 17° 21′ from either node, at the time of new moon, the sun may be eclipsed; or if less than 11° 34′ from either node, at the full moon, the moon may be eclipsed; at all other times there can be no eclipse, for the shadow of the moon will fall either above or below the earth at the time of new moon; and the shadow of the earth will fall either above or below the moon at the time of full moon. Eclipses are now of certain calculation. It was, however, believed by the ancients that their number depended on chance. An eclipse of the sun begins on the western side of his disc, and ends on the eastern; and an eclipse of the moon begins on the eastern side of her disc, and ends on the western. The average number of eclipses in a year is four, two of the sun and two of the moon; and, as the sun and moon are as long below the horizon of any particular place as they are above it, the average number of visible eclipses in a year is two, one of the sun and one of the moon.

The precise character of this species of eclipse can only be explained by reference to a diagram.



The sun is represented at *a*, and a ray at *b* is seen to pass from the extremity of the sun's disc. Another ray passing from the centre, or from the direction of *c*, ends at *d*; for there the light will be intercepted by the moon, *e*, and the same will also occur by the ray *b f k*. The *umbra* formed on the earth's surface will thus be much smaller than the moon, while the *penumbra*, on the contrary, will considerably exceed it in magnitude. The size of the umbra is shown at *h i*, and the penumbra at *g k*. Now, the portion of a circle, delineated at *d f*, represents the moon's orbit, and it will be obvious that, if the orbit was always in the same relative position with reference to the sun and earth, eclipses would be of very frequent recurrence; such, however, is not the fact, as it is either above or beneath that position on most occasions.

Ecliptic; the sun's path; the great circle of the celestial sphere in which the sun appears to describe his annual course from west to east. The Greeks observed that eclipses of the sun and moon took place near this circle; whence they called it the *ecliptic*, from *eclipses*. By a little attention, we shall see that the sun does not always rise to the same height in the meridian, but seems to revolve round the earth in a spiral. We likewise observe every day, at its rising and setting, new stars in the neighbourhood of the sun. It will also be seen that the sun is in the equator twice a year; about March 22 and September 22.

The points of the equator at which the sun is stationary, on these days, are at the intersection of the equator with the ecliptic. June 21, the sun reaches its greatest height in the heavens; and December 21, it descends the lowest. Because the sun appears to turn back at these points, they are called the *tropics*; and the times at which the turning appears to commence are called *solstices* (*solstitia, solis stationes*). At these points, the sun has attained its greatest distance from the equator. These four points, the equinoctial and solstitial points, are distant from one another a quarter of a circle, or 90 degrees. Each of these quadrants, or quarters of a circle, is divided into 3 equal arcs of 30 degrees; thus the whole ecliptic is divided into 12 equal arcs or signs: these receive their names from certain constellations through which the ecliptic passes, and which extend each 30 degrees, and are some of them of a very picturesque character.

The constellations, or 12 celestial signs, succeed one another in the following order, from the vernal equinox, reckoned towards the east:

♈ Aries, March 20.
♉ Taurus, April 20.
♊ Gemini, May 21.
♋ Cancer, June 21.
♌ Leo, July 22.
♍ Virgo, August 23.
♎ Libra, September 23.
♏ Scorpio, October 23.

♐ Sagittarius, November 22.
♑ Capricornus, December 21.
♒ Aquarius, January 19.
♓ Pisces, February 18.

The days of the month annexed show when the sun, in its annual revolution, enters each of the signs of the zodiac. The 30 degrees in every sign are divided into minutes and seconds, not reckoned separately, but after the signs. An arc of the ecliptic, for example, of 97° 15′ 27″, reckoned from Aries, eastward, is called 3 signs, 7° 15′ 27″ long, or, what is the same thing, it terminates in 7° 15′ 27″ of Cancer. In this way the longitude of the stars is given.

The ecliptic, like all circles, has two poles, which move about the poles of the earth every 24 hours, and in this manner describe the polar circles. What appears to be the path of the sun, however, is, in reality, the path of the earth. The planets and the moon revolve in different planes; but these are inclined at only a very small angle to the plane of the ecliptic; hence these bodies can be but a small distance from the ecliptic. The plane of the ecliptic is very important in theoretical astronomy, because the courses of all the other planets are projected upon it, and reckoned by it.

By the obliquity of the ecliptic, we understand its inclination to the equator, or the angles formed by the planes of these two great circles. This angle is measured by the arc of a third great circle, drawn so as to intersect the two others perpendicularly in the points at which they are farthest apart. These points of intersection are 90 degrees distant from those points at which the equator and ecliptic intersect each other, i. e. the solstitial points. The ancients endeavoured to measure the obliquity of the ecliptic. According to Pliny, it was first determined by Anaximander; according to Gassendi, it had been ascertained by Thales. The most celebrated measurement of this obliquity, in ancient times, was made by Pytheas, at Marseilles. He found it, 350 B. C., to be 23° 49′ 23″. A hundred years later, according to Ptolemy, Eratosthenes found it to be 23° 51′ 20″. Various measurements have subsequently taken place, even down to our own time; and it is remarkable that almost every measurement makes the angle less than those which preceded it. Among the modern estimates are that of Cassini, 23° 28′ 35″; of La Caille, 23° 28′ 19″; of Bradley, 23° 28′ 18″; and of Mayer, 23° 28′ 16″: the observations of Delambre, Maskelyne, Piazzi, Bessel, and others, give this important astronomical element, for the year 1800, at 23° 27′ 56″.

In respect to the decrease of the inclination of the ecliptic, the most celebrated astronomers of our time, as Lalande, adopted the opinion that this decrease continues uninterruptedly. Louville determined the annual decrease to be 1′, La Caille 44″, and Lalande 33″. Several philosophers, of modern times, concluded, from these observations, that the equator and the ecliptic were formerly in the same plane; that the shock of a comet, or some mighty revolution on the earth, gave the axis of our planet this inclination, and that, for thousands of years, the axis has been returning to its original position, which it will reach after 190,000 years. Laplace, on the contrary, in his *Mécanique Céleste*, showed that this could never take place, but that the decrease of the angle between the planes of the equator and the ecliptic depends merely upon a periodical effect, arising from the action of the other planets; that, after a certain time, it will increase again, and that the limits of variation are narrow and fixed. A very long space of time will be required to make satisfactory observations respecting this fact. The inclination of the ecliptic, or, which is the same thing, the inclination of the axis of the earth towards the ecliptic, is subject to another change, which makes it increase and decrease, alternately, for nine years, during which time the greatest difference amounts to 18″.

Eddies are irregular movements of water or of wind, or those deviations from the principal direction of the whole stream which are occasioned by obstacles of any kind. When these irregular motions become rotary or circular about a certain centre, they assume the title of whirlpools. (See Whirlpool and Whirlwind.)

Edulcoration; the process of freeing a difficultly soluble substance from one that is easily soluble, by means of distilled water. It differs little from lixiviation, except that the former term respects the insoluble residue, and the latter the soluble portion. Thus we say, to lixiviate wood ashes, because the object of the process is to procure the soluble alkaline ingredient separate from the earth and other impurities with which it is mixed; and, on the other hand, we say, to edulcorate the precipitate from alum, when the intention of the operation is to obtain the earth quite pure from soluble matter.

Effervescence, in *chemistry*, is a rapid disengagement of gas taking place within a liquid; in consequence of this numerous bubbles rise to the surface, forming a head of froth, and bursting with a hissing noise. There is some resemblance between effervescence and fermentation; the latter, although the source of the gas, in process is very different. Hence chemists formerly applied the term fermentation to all the phenomena which are at present denoted by effervescence. Gas produced by effervescence is by means of single or double elective affinity; in the one case it is generally carbonic acid gas, in the other it is either nitrous gas or hydrogen. Gas can have but little affinity with the fluid in which it is immersed, in order to produce effervescence. Thus, carbonic and muriatic acids are both gases, and are both extricated from alkaline combinations by sulphuric acid; yet a solution of carbonate of potash in water will produce a vehement effervescence with sulphuric acid, while muriate of potash in the same circumstances will occasion none at all, the carbonic acid having a very slight affinity for water acidulated by sulphuric acid, while the muriatic acid will combine with the same very readily.

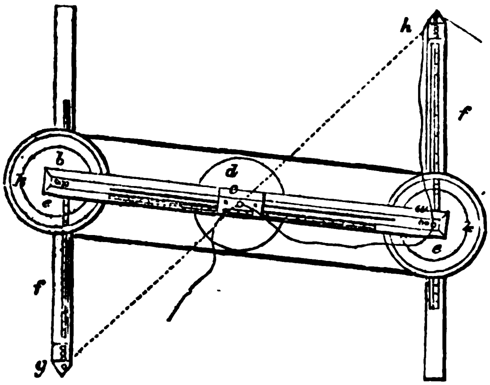
Efflorescent, in *chemistry*; a term applied to those crystals which, by parting with a portion of their water by exposure to air, crumble as though pulverized.

Eidograph. A very ingenious drawing instrument, under this title, has been invented by Professor Wallace, and described by Sir David Brewster. It is a fact well known, that artists of various descriptions, who have frequent occasion to imitate original designs, have long felt the want of a convenient mathematical instrument, by which a copy may be made with neatness and expedition, that shall have any given proportion to the original. The pantograph is the only instrument that has been successfully employed; but, although correct and plausible in theory, in practice it is found to be so very imperfect,

that the artist hardly ever thinks of making use of it.

A consideration of the essential service that would be rendered to the graphic art, by a copying instrument which should be at once simple in its theory and easy in its application, induced Mr. Wallace to turn his attention to the subject; and, in the summer of 1821, he produced a model of a copying instrument, which he has denominated an eidograph. The instrument, and its application to the copying of a very great variety of subjects, has been shown to engineers, engravers, and other competent judges in London and in Edinburgh, and their opinion of its utility has been such as to leave no doubt of its completely fulfilling the views of the inventor.

The instrument is represented in the accompanying figure.



The principal or central beam, which is made of mahogany, slides backward and forward in a socket in the centre; the socket turns on a vertical axis, supported by a fulcrum, which stands on a table. There is a slit in the beam, through which the axis of the socket passes, so that when the beam slides in the socket a portion of it passes on each side of the axis. There are two equal wheels, below the beam, which turn on axes that pass through pipes fixed at *a*, *b*, near its extremities; and a steel chain passes over the wheels as a band, by which a motion of rotation may be communicated from the one to the other. There are two arms, *f*, *f*, which slide in sockets along the lower face of the wheels, just under their centres: at the extemity, *g*, of one arm, there is a metal tracer, with a handle attached to it, by which its points may be carried over the lines in any design; and at *h*, the extremity of the other arm, there is a black-lead pencil fixed in a metal tube, which is ground to fit so exactly into a pipe as just to slide up or down. In using the instrument, the pencil in its tube is raised by a thread which passes over a pulley, and it descends again by a weight with which it is loaded.

From the perfect equality of the wheels, it is easy to see that, if the arms attached to them be placed parallel in any one position, they will retain their parallelism, although one of the wheels, and consequently both, be turned on their centres. Supposing, now, that *b*, *c*, and *a*, *c*, the parts into which the axis is divided at the centre, have any proportion whatever to each other, if the distances of the tracing point, *g*, and pencil point, *h*, from the centres of their wheels have the very same proportion, then it follows, from the elements of geometry, that the tracing point *g*, the centre *c*, and the pencil point *h*, will be in a straight line; and farther, that *c*, *g*, and *c*, *h*, the distance of these points from the centre, will have to each other the constant proportion of *c*, *b*, to *c*, *a*, or of *e*, *g*, to *a*, *h*. Such being the geometrical property of the eidograph, if any subject to be copied be fixed to the table on which the instrument stands, and the tracing point be carried over every line of the design, the pencil point will trace a copy in all respects similar to the original. To facilitate the adjustment of the instrument, so that the copy may have any given ratio to the original, there are scales of equal parts on the beam and the two arms. By these and verniers, both halves of the beam, and equal lengths on the arms, are each divided into one thousand equal parts, and at certain intervals corresponding numbers are marked on them. By means of the scales, when any ratio is assigned, the adjustment is made without the least difficulty.

To avoid any derangement by the chain slipping on the wheels, there are clamps provided, which hold it fast to the wheels at points where it never quits them. They are slackened when the instrument is adjusted.—*Scientific Gazette.*

Elain; the oily principle of fat, obtained by submitting fat to the action of boiling alcohol, allowing the stearin to crystallize, and then evaporating the alcoholic solution; or, by the simple process of pressing any oily or fatty substance between folds of bibulous paper, the oily matter or elain is absorbed, while the stearin remains. The paper being then soaked in water, and pressed, yields up the elain. It possesses much the appearance and properties of vegetable oil, is liquid at the temperature of 60° Fahr., and has an odour derived from the solid fat from which it has been extracted. It is readily soluble in alcohol, and forms soaps with alkalies; in doing which, however, it undergoes decomposition, and is converted, according to Chevreul, into a peculiar acid, called by him *oleic acid*, which combines with the alkali employed. This acid is obtained by submitting the soap formed by the action of potash on hog's lard to the action of boiling water; the solution, on cooling, deposits a sediment, consisting of the margarate of potash, while the oleate of potash remains in solution. The oleate of potash is decomposed by tartaric acid, again combined with potash, and again decomposed by tartaric acid, when the oleic acid rises to the top in the condition of an oily-like fluid. It is insoluble in water, soluble in alcohol, reddens litmus, and combines with the different salifiable bases, forming compounds somewhat analogous to soaps. At a temperature of 35° Fahr. it congeals into crystalline needles.

Elasticity; the peculiar property of bodies, by virtue of which the particles of which they are composed, when moved out of their positions by an external force, or pressed into a narrower space, tend to return to their former position, as soon as the external force ceases to act. A bow, bent by the tension of the string, recovers its previous form when the tension is relaxed.

Let an ivory ball fall upon a plate of marble, it is partially flattened by the impulse, but becomes immediately round again as soon as the force of the blow is destroyed. Here we see the cause of its rebounding from the hard surface. This property of elasticity is particularly observable in atmospheric

air. If it is enclosed in a vessel, and pressed with a piston, as soon as the force is removed from the piston, the air throws it up violently. This is the principle of the air-gun. There is an important difference between the elasticity of solids and fluids: the former tend to recover their previous form; the latter to expand into a greater space, whence the term *expansibility* is applied to them. For the sake of distinction, the elasticity of solid bodies may be termed attractive, and that of fluids expansive. The degree of it is very different in different bodies, and in many it is increased by art. Those bodies in which it cannot be perceived at all are called *unelastic*.

The elasticity of a solid body is greater the more its particles are expanded. If all the particles of a body are so far expanded that their elasticity is just equal to the expansive power, the expansion can be carried no farther without separating the particles. The weights necessary to produce a given degree of extension must be proportionate to the extension already existing. If three cords, of the same size and substance, stretched in proportion to the numbers 1, 2, 3, are to receive each a given amount of additional extension, the weights necessary to produce this extension are as 1, 2, 3.

The laws of elasticity in fluids are different from those in solids. In heavy elastic fluids, the inferior layers support the weight of the superior; in a cylindrical vessel, therefore, the bottom suffers the pressure of the whole mass of elastic fluid, and the lower strata are sensibly denser than the upper. A difference is made, too, between absolute and specific elasticity. By the former is understood the peculiar property of bodies to repel a pressing force, in itself, and without regard to temperature and density. This must be always equal to the pressing force. But, as different kinds of matter may press with equal force under unequal densities and temperatures, that is called specifically most elastic which with a less density presses with a force equally strong, and with an equal density stronger. In all elastic fluids, the specific elasticity increases with the temperature; it is likewise augmented by greater density: if air is confined, and made more dense, its specific elasticity is greater in proportion to its increase of density.

Elbow, in *anatomy*, is the joint formed between the *humerus*, *radius*, and *ulna*.

Elbow is also used by masons, architects, &c., for an obtuse angle of a wall, building, or road, which diverts it from its right line.

Elder; a name given to the different species of the genus *sambucus*. The uses of the elder are more numerous than those of most other shrubs. There is scarcely any part of it which has not been advantageously employed in some way or other. The wood is yellow, and in old trees becomes so hard that it will receive a polish almost as well as box, and indeed is often used as a substitute for box-wood. It is likewise employed by turners. Sir J. E. Smith has remarked that this tree is, as it were, a whole magazine of physic to rustic practitioners, and is not quite neglected even by professional men. Ointments have been made of the green inner bark, and of the leaves. The dried flowers, infused in water, are used in fomentations or as tea, and, mixed with buttermilk, have sometimes been used as a wash for the face. An infusion of the leaves is sometimes sprinkled by gardeners over the buds of such flowers as they wish to preserve from caterpillars. Elder flowers have an agreeable flavour, which they impart in distillation to water; they are likewise used to give a flavour to vinegar. The berries are poisonous to poultry, but their juice, properly fermented, makes a pleasant and wholesome wine, and in Germany a very pure and strong spirit is distilled from them. The juice of elder berries is sometimes employed to give a red colour to raisin or other sweet wines. The young shoots of this shrub are filled with an exceedingly light pith, which is cut into balls for electrical experiments, and is also made into toys for the amusement of children. The elder will thrive in almost any soil and situation; and every part of it has an unpleasant narcotic smell, which ought to render people cautious not to sleep under its shade, since, in such case, it might prove of serious injury to them.

Elecampane is a plant inhabiting the Eastern continent, and now naturalized and frequent in many parts of the United States, where it grows along roadsides, waste places, &c. This root possesses a bitter aromatic and somewhat acrimonious taste, and has been celebrated in disorders of the breast and lungs; it is useful to promote expectoration, and is also sudorific.

Electric Column, or aërial electroscope; an instrument composed of a great number of small circular and very thin plates (about the diameter of a sixpenny piece of silver) of paper and of zinc, alternately arranged, forming a column, the two ends of which are made to approximate, and at each of them is attached a small bell; a metallic clapper is then hung between them, and the whole apparatus is insulated by being fixed on glass stands. One end of the column is observed to become electrified plus, as it is termed, and the other minus; consequently, one of the bells becomes electrified plus or positive, and the other minus or negative: and the metallic clapper moving rapidly from one to the other, to equalize the two electricities, a pulsation is produced, and the bells ring. Neither the heat nor cold, dryness nor moisture, of the atmosphere, appears to have any considerable influence on the action of this instrument; but it is considerably altered by peculiarities in the electric state of the atmosphere. The prevalence of cirri ramifying about the sky in various directions, and accompanied often by other modifications, by dry, easterly, and changeable winds, and by numerous small meteors of an evening, which appear to indicate a disturbance in the atmospherical electricity, is found to be accompanied by an irregular action of the electric column.

Electrical Eel; a fish possessing the extraordinary property of communicating a sensation similar to an electrical shock, when touched with the hand, or an electric conductor. The seat of the organs which produce this curious effect is along the under side of the tail. They are composed of four bundles of parallel membraneous laminæ, placed very near each other, and nearly horizontally, extending from the skin to the central medial plane of the body, connected together by numerous vertical laminæ, arranged transversely. The little cells, or rather the small prismatic and transverse canals, intercepted by these two kinds of laminæ, are, according to Cuvier, filled with a gelatinous substance; and the whole apparatus is abundantly supplied with nerves.

Electrical eels are of several species, the most celebrated of which is the *gymnotus electricus*, found in the rivers of South America. It is said to possess power, when in full vigour, sufficient to knock down a man, and benumb the limb affected, in the most painful manner, for several hours after communicating the shock. By frequent use of this faculty it becomes impaired, and a considerable interval of rest is required to recruit its electrical properties. Through the medium of water, it is able to destroy small fishes at a considerable distance, directing the power at pleasure. Some authors aver that the *gymnotus* is found so large and powerful as to benumb a horse, and to drown men while bathing, by the violence of the shock.

A specimen of the *gymnotus*, which was conveyed alive to England some years since, afforded the curious an opportunity of verifying the reports of travellers as to its electric property. Since that period, numerous specimens have been examined, and the preceding observations confirmed. The property of communicating electrical shocks is common to some other fishes, of the same subdivision. Specimens of the *gymnotus electricus* are reported to attain the length of six or seven feet, but ordinarily they are about three and a half or four feet long. The flesh is eatable, and, in appearance and flavour, is said to resemble that of an eel.

Electricity; a branch of natural philosophy, which investigates the attractions and repulsions, the production of light, and the elevation of temperature, as well as the explosions and other phenomena attending the friction of vitreous, resinous, and metallic surfaces, and the heating, cooling, evaporation, and mutual contact of a great number of bodies. Its name is derived from the Greek word for *amber*, in which substance its phenomena were first observed. The knowledge which the ancients were possessed of, concerning this interesting and now very extensive branch of science, consisted in little more than the fact that amber acquired the power of attracting to itself light bodies, on being rubbed, ascribed by Thales, of Miletus, to an inherent soul or essence, which, awakened by friction, went forth, and brought back the light particles floating around.

In the year 1600, Dr. Gilbert, an English physician, published a treatise upon the magnet, in which he remarked that several other bodies besides amber can, by friction, be made to attract light bodies. The observations of Boyle, Otto Von Guericke, Newton, and a few other philosophers of the same period, contributed somewhat to the extension of our knowledge of electricity; but it was not before the middle of the 18th century, that the most important discoveries and generalizations of the phenomena before known upon this subject were made.

The order we shall adopt in the present article will be the following: 1. *A general statement of electrical phenomena, independent of all theory*. 2. *The theories which have been proposed for explaining these phenomena*. 3. *Electrical machines*. 4. *Effects of electrical attraction and repulsion*. 5. *Distribution of electricity*. 6. *Transference of electricity*. 7. *Laws of induction*. 8. *Motion of electricity*. 9. *Chemical effects of electricity*. 10. *Effects of electricity upon living bodies*. 11. *Electricity developed by changes of temperature and of form, from contact, compression, and other changes in bodies*. 12. *Electricity of the atmosphere*.

1. A dry glass rod, or a piece of amber or sealing-wax, when rubbed rapidly with a dry woollen cloth, and immediately presented to light bodies, such as fragments of paper, thread, cork, straw, cotton, or gold leaf, will first attract and then repel them. The bodies which have thus acquired this attractive and repulsive power are said to be excited. All substances, however, are not capable of being easily excited; hence the distinction of bodies into classes—electrics, and non-electrics.

The principal electric substances may be thus enumerated: amber, gum-lac, resin, sulphur, glass, the precious stones, silk, the fur of most quadrupeds, and almost all vegetable substances which have been thoroughly deprived of moisture, as baked wood, and dry paper. If the light bodies which have been repelled from an excited electric be again presented to it, they will, provided they have touched no other body, continue to be driven off. Some substances remain in contact with the electric longer than others; fibres of cotton adhere some time, while metallic bodies are repelled the instant after contact. Two bodies, which have both been in contact with the same electric, mutually repel each other.

If a glass tube of considerable diameter, and two or three feet in length, be employed for the experiment, we notice in a dark room, during the friction, flashes of light, of a bluish tinge, extending over every part of the tube; and sparks, attended with a sharp snapping sound, will be seen to dart out in every direction. If we present to it, after rubbing, a round metallic ball, sparks will be obtained as the ball approaches the tube; and, if the knuckle be presented instead of the ball, the same effect takes place, accompanied with a pricking sensation.

If a metallic ball be suspended in the air by silk, thread, or fibres of worsted or hair, or a rod of glas , and rubbed while in this situation by an electric, it will exhibit the same properties of attraction and repulsion as if it had been itself an electric. That the ball should thus be cut off from contact with any substance, except the air and the electric which sustains it, is essential to the success of the experiment.

Should an excited electric be placed near a light pith ball suspended by silk, the ball will, in the first place, approach the electric, but after contact will recede from it. If now, uncovering the electric, we present to the ball which has thus touched it a second ball, similarly suspended, but which has had no previous communication with any electric, we shall find that these two balls will attract one another, and come into immediate contact. The same results are repeated between this second ball and a third, which may be presented to it, and so on in succession, with a continued diminution, however, in the rapidity of the movements, indicative of a diminished power, in consequence, as it would seem, of its being distributed among a number of bodies.

From these facts we infer that the electric imparts to the balls, suspended as above, properties exactly similar to those which had been excited in itself by friction. By repeated contact with a number of bodies, an excited electric is found to lose its electrical powers, in the same degree as these powers have been acquired by the bodies themselves; and fresh excitation alone can renew them. It is evident, therefore, that electricity is capable of being transferred, in the same sense as caloric, of which we

speak as being communicable, and, like caloric, it is weakened by diffusion among a number of bodies. If an electrified ball be touched with the finger or by a rod of metal, it will be deprived of the whole of its electricity, which will pass to the finger or rod touching it; the ball being left in its original or natural state, and again becoming susceptible of being attracted, either by an excited electric, or by another body to which electricity has previously been communicated. If a rod of glass be applied, instead of the finger or metallic rod as above, the body touched remains unaffected, notwithstanding the contact.

We are thus led to conclude that some substances, such as glass, are incapable of conducting electricity; while others, such as metals, and the human body, readily conduct it. And it is found that all *electrics* are *non-conductors*, while, on the contrary, *conductors* are *non-electrics*. The permanence of electricity in metallic bodies, suspended in the air by silken threads, proves that the air, as well as silk, is a non-conductor, from which circumstance bodies surrounded by it, except on one side, and this side being in contact with a non-conductor, are said to be *insulated*. If this condition be not observed, that is, if a body be in contact with conducting substances which communicate with the earth, its electricity will escape through them to the earth, which may be regarded as the great reservoir both for the absorption and supply of this fluid.

The insulating power of the atmosphere depends upon its density and its dryness. In proportion as the air is rarefied by the removal of the superincumbent pressure, its power of confining electricity diminishes, till at length, when the rarefaction is very great, it opposes scarcely any resistance to the passage of electricity. The presence of moisture in the air also diminishes its insulating power.

Water is a good conductor of electricity; accordingly, any portion of it suspended in the air tends to carry off electricity from bodies charged with it, and which are immersed in such an atmosphere. Moisture also easily attaches itself to glass and other electrics, depriving them of the power of insulation. Hence we discover the reason why experiments which succeed in a clear, dry day, will often fail in damp weather, and the utility of drying all the instruments employed in electrical experiments, in order to exclude, as much as possible, the interference arising from the presence of condensed moisture.

The conducting powers of most bodies are influenced by changes of temperature, and also of form. Thus water, in its liquid state, is a good conductor; but when in the state of ice, at a temperature of 13° Fah., it is a non-conductor, and capable of being excited by friction like any other electric. Reducing substances to powder has an effect upon their powers of conducting electricity. Snow conducts less readily than ice at the same temperature; but glass, as well as sulphur, on the contrary, acquire some conducting power by being pulverized.

Vegetable and animal substances lose their conducting powers when made thoroughly dry. No substance with which we are acquainted can be said to be wholly impervious to electricity; nor, on the other hand, is there any body which opposes no resistance to the transmission of electricity.

The following table presents a view of the principal classes of bodies, arranged in a series, beginning with those possessed of the greatest conducting power, and terminating with those that have the least. The order in which they possess the power of insulating is, of course, the reverse of this:—

The perfect, or least oxidable metals.	Metallic ores.
The more oxidable metals.	Animal fluids.
Charcoal prepared from the harder woods, and recently ignited.	Water.
Plumbago.	Snow.
The concentrated mineral acids.	Living vegetables.
Dilute acids.	Living animals.
Solutions of metallic salts.	Smoke.
	Steam.
	Rarefied air.
	Earths and stones in their natural state.
	Pulverized glass.
	Flowers of sulphur.

———

Dry metallic oxides.	and other gases.
Oils.	White sugar.
Vegetable ashes.	Dry parchment.
Animal ashes.	Cotton.
Ice below 13° Fah.	Feathers.
Phosphorus.	Hair, especially that of a living cat.
Lime.	Silk.
Dry chalk.	Transparent gems.
Caoutchouc.	Diamond.
Camphor.	Glass.
Silicious and argillaceous stones, in proportion to their hardness.	Fat.
Porcelain.	Wax.
Baked wood.	Sulphur.
Dry atmospheric air,	Resins.
	Amber.
	Gum-lac.

Although the exact point in the above scale which forms the separation between conducting and insulating bodies cannot be precisely marked, yet we have indicated it by a division. The laws which regulate the gradual dissipation of electricity from imperfectly insulated bodies have been carefully investigated by M. Coulomb.

The causes which operate in these circumstances are, 1. the imperfection of the insulating property in the solids by which they are supported; 2. the contact of successive portions of air, every particle of which carries off a certain quantity of electricity; 3. the deposition of moisture upon the surface of the insulating bodies, which establishes communications between their opposite ends, and may be considered as virtually increasing the conducting power. Still another circumstance, which materially affects the dissipation of electricity, is the shape of the body in which it is accumulated. The form most favourable for its retention is that of a sphere; next, a cylinder terminated at both extremities by a hemisphere. On the other hand, electricity escapes most readily from bodies of a pointed figure, especially if the point projects to a distance from the surface. In such bodies, it is scarcely possible to retain any accumulation of the electric fluid; whereas pointed bodies receive electricity more readily than those of any other form.

Electric excitation in different bodies exhibits different phenomena. We have seen that light substances excited by glass repel one another, and are likewise repelled by the excited glass. The same thing also happens with respect to bodies which have re-

ceived their electricity from excited sulphur or sealing-wax. But, on examining the action of any of the bodies of the former class upon any of those belonging to the latter, we find that, instead of repelling, they attract each other; and, what is still more remarkable, the instant these bodies come in contact, provided they have both been electrified in an equal degree, they cease at once to exhibit any signs of electrical excitement, the electricity in the one appearing to neutralize that in the other.

Thus we seem to have evidence of two kinds of electricity; and as these were first noticed, the one in glass and the other in resinous bodies, they were named *vitreous* and *resinous* electricity. Their mode of action on matter has been expressed by the following general law, viz.: *Bodies charged with either species of electricity repel bodies charged with the same species, but attract bodies charged with the other species; and, at equal distances, the attractive power in the one case is exactly equal to the repulsive power in the other.* Accordingly, we learn the kind of electricity with which a given body is charged, by approaching it to an insulated pith ball, which has previously been touched either with excited glass, or with excited sealing-wax It is known, moreover, that, when two electrics are rubbed against one another, the one acquires, always, one kind of electricity, the other the opposite; and both are produced in equal degrees. Thus, when glass is rubbed by silk or flannel, just as much resinous electricity is produced by the silk or flannel as there is vitreous electricity produced in the glass; and consequently, as they are endowed with opposite electricities, there should be an attraction existing between the excited surfaces of the bodies rubbed.

The above fact is easily proved by the simple and familiar experiment of the ribbons. If a white and black ribbon, of two or three feet long, and perfectly dry, be applied to each other by their smooth surfaces, and then drawn repeatedly between the finger and thumb, so as to rub against each other, they will be found to adhere together, and, if pulled asunder at one end, will rush together with great quickness; while united, they exhibit no sign of electricity, because the operation of the one is just the reverse of that of the other, and their power is neutralized and inoperative. If completely separated, however, each will manifest a strong electrical power, the one attracting those bodies which the other repels.

The causes that determine the species of electricity excited, in the respective bodies of which the surfaces are made to rub against each other, have not been satisfactorily ascertained. The mechanical configuration of the surfaces appears to have more influence on the result than the nature of the substances themselves. Thus smooth glass acquires vitreous electricity by friction with almost every substance, except the back of a cat, which induces the resinous electricity; but roughened glass, if rubbed with the same substances, becomes chargeable with resinous electricity, while the rubbing bodies acquire the vitreous. Silk, rubbed by resin, takes the vitreous, but polished glass the resinous electricity.

The following is a list of several substances which acquire vitreous electricity when rubbed with any of those which follow them, in the order in which they are set down; and resinous electricity, if rubbed with any of those which precede :—

The back of a cat.	Paper.
Polished glass.	Silk.
Woollen cloth.	Gum-lac.
Feathers.	Roughened glass.
Wood.	

In the experiment above mentioned of the silk ribbons, the black ribbon exhibited the vitreous and the white one the resinous electricity. But when the ribbons are differently excited, as the one being drawn lengthwise and at right angles over a part of the other, the one which has suffered friction in its whole length acquires vitreous, and the other resinous electricity. Indeed the slightest difference in the conditions of these and similar experiments, or the species of electricity arising from friction, will be often sufficient to produce opposite results.

Another important observation, with regard to electrical phenomena, requires to be stated previously to our conclusion of the present head. Whenever a body is charged with electricity, although it be perfectly insulated, it tends to produce an opposite electrical state in all the bodies in its vicinity, and this with greater energy in proportion as the distance is smaller. This effect is termed the *induction* of electricity. In consequence of this law, if an electrified body, charged with either species of electricity, be presented to an unelectrified or neutral body, the electrical condition of the different parts of the neutral body is disturbed. The electrified body induces a state of electricity contrary to its own in that part of the neutral body which is nearest to it, and consequently a state of electricity similar to its own in the remote part. Hence, the neutrality of the second body is destroyed by the action of the first; and the adjacent parts of the two bodies, having now opposite electricities, will attract each other. It thus appears that the attraction which is observed to take place between electrified bodies and those that are unelectrified is merely a consequence of the altered state of those bodies, resulting directly from the law of induction.

II. The hypothesis which naturally suggests itself for the explanation of the phenomena above stated is that of a very subtle, imponderable, and highly elastic fluid, pervading all natural bodies, and capable of moving with various degrees of facility through the pores or actual substance of different kinds of matter. In some, as in those we call *conductors* or *non-electrics*, it moves without any apparent obstructions; while in others, as in those we call *non-conductors* or *electrics*, it moves with difficulty.

As the phenomena appear to indicate the agency of two kinds of fluid, we shall, for the present, assume the existence of two species, and shall speak of these under the names of the *vitreous* and the *resinous electricities*. They must each have, when separate, the same general properties as have already been enumerated above; while, in relation to each other, there must be a complete contrariety in their nature, so that, when combined together, their action on the bodies in their immediate vicinity shall cease. And it is when existing in this state of union or neutrality that bodies are said to be in their natural state as respects electricity. We shall now proceed to compare the suppositions we have made with the facts, as presented to us by nature, and developed by experiment.

Facts connected with *excitation*. From various

causes (of which the friction of surfaces is one), the state of union in which the two electricities exist in bodies, is disturbed: the vitreous electricity is impelled in one direction, while the resinous is transferred to the opposite; and each manifests its peculiar powers. When accumulated in any body, each fluid acts in proportion to its relative quantity, that is, to the quantity which is in excess, above that which is still retained, in a state of inactivity, by its union with electricity of the opposite kind. Thus, when glass is rubbed with a metallic amalgam, a portion only of the electricities at the two surfaces is decomposed: the vitreous electricity resulting from this decomposition attaches itself to the glass; the resinous to the amalgam. What remains in each surface undecomposed, continues to be quite inert.

Facts connected with *distribution*. Both of these fluids being highly elastic, their particles repel one another with a force which increases in proportion as their distance is less; and this force acts at all distances, and is not impeded by the interposition of bodies of any kind, provided they are not themselves in an active electrical state. It has been deduced from the most careful analysis that this force follows the same law with that of gravitation: viz. that its intensity is inversely as the square of the distance.

The mode in which the electricity imparted to a conducting body, or to a system of conductors, is distributed among their different parts, is in exact conformity to the results of this law, as declared by mathematical investigation. While the particles of each fluid repel those of the same kind, they exert an equally strong attraction for the particles of the other species of electric fluid. This attraction, in like manner, increases with a diminution of distance, and follows the same law as to its intensity: viz. that of the inverse ratio of the square of the distance. This force, also, is not affected by the presence of any intervening body.

Facts connected with *transferrence*. Since the two electricities have this powerful attraction for each other, they would always flow towards one another, and coalesce, were it not for the obstacles thrown in their way by non-conductors. When, instead of these, conducting substances are interposed, they enter into union with great velocity, producing, in their transit and confluence, several remarkable effects.—When once united, their powers remain dormant, until again called into action by the renewed separation of the fluids.

Facts relating to *attraction and repulsion*. The repulsion which is observed to take place between bodies that are insulated, and charged with any one species of electricity, and other bodies similarly charged, is derived from the repulsive power which the particles of this fluid exert towards those of their own species; and the attractions between bodies differently electrified is derived from the attractive power of the vitreous particles for those of the opposite kind. In all cases the movements of electrified bodies represent the forces themselves which actuate the particles of the developed electricities they contain.

Facts relating to *induction*. Wherever one of the electricities exists in an active state, it must repel all the particles of the same electricity in all surrounding bodies, and attract those of the opposite species. Thus the law of induction is seen to be a direct consequence of the hypothesis we are considering.

Thus far we have proceeded upon the hypothesis of two distinct electric fluids. It was, however, discovered by Franklin that it is equally easy to account for these phenomena, on the supposition of their resulting from the agency of a single electric fluid. This theory supposes that the single agent in question, and which we shall call the *electric fluid*, is highly elastic, or repulsive of its own particles,—the repulsion taking place with a force varying inversely as the square of the distance; that its particles attract and are attracted by the particles of all other matter, following the same law of the inverse square of the distance; that this fluid is dispersed through the pores of bodies, and moves through them with various degrees of facility, according as they are conductors or non-conductors.

Bodies are said to be in their natural state, with regard to this fluid, when the repulsion of the fluid they contain of a particle of fluid at a distance is exactly balanced by the attraction of the matter in the body for the same particle; and, under these circumstances, they exhibit no electrical phenomena. But if subjected to certain operations, as friction, the equilibrium is destroyed, and they acquire more or less than when in their natural state. Whenever they acquire a quantity of fluid greater than in their natural state, they are said to be *positively* electrified, or electrified *plus*, and present the phenomena ascribed to what was called *vitreous* electricity. When, on the other hand, there is a quantity less than what is required in order to be in their natural state, they are said to be *negatively* electrified, or to be electrified *minus*, in which case they correspond with the state of resinous electricity.

The state of positive electricity, then, consists in a redundance of the electric fluid, or in matter over-saturated with this fluid; that of negative electricity, in a deficiency of fluid, or in matter under-saturated, or, what may be considered the same thing, in redundant matter. In considering the mutual electrical actions of bodies, the portions in which the matter and the fluid mutually saturate each other need not be taken into account, since their actions, as we have seen, are perfectly neutralized; and we need only attend to those of the redundant fluid and the redundant matter.

When a body contains more than its natural proportion of electric fluid, the surplus will, by the repulsive tendency of its particles, overflow and escape, unless prevented by insulation, until the body is reduced to its neutral state.

When under-saturated, the redundant matter will attract fluid from all quarters from which it can receive, until it is again brought to its natural state. The mutual recession of two positively electrified bodies is a direct consequence of the redundance of the electric fluid contained in each, this fluid being attracted to the matter by its attraction for it in both bodies; and, the fluid in one being repulsive of the fluid in the other, the bodies are necessarily impelled in the direction of the repulsion. In the same manner, the mutual attraction between two bodies, one of which is electrified plus and the other minus, is the immediate effect of the attraction of the redundant fluid in one for the redundant matter in the other, and *vice versâ;* for this attraction is mutual.

The mutual recession of two bodies, negatively electrified, does not appear to be accounted for upon the Franklinian theory. In order to do this, therefore,

it has been found necessary to append to it the following provision; that particles of simple matter, or bodies unsaturated with the electric fluid, are mutually repulsive. Without this provision, indeed, we are unable to explain the want of action between two neutral bodies; for, the repulsion of the fluids in both bodies being balanced by the attraction of the fluid in the one for the matter in the other, the remaining attraction of the fluid in the second body for the matter in the first would be uncompensated by any repulsion, and the forces would not be held in equilibrium, as we find they really are.

The law of electrical induction is an immediate consequence of the Franklinian theory. When a body charged with electricity is presented to a neutral body the redundant fluid of the former exerts a repulsive action on the fluid of the latter body; and, if this happens to be a conductor, it impels a certain portion of that fluid to the remote end of this body, which becomes at that part positively electrified; while its nearer end, which the same fluid has quitted, is consequently in the state of negative electricity. If the first body had been negatively electrified, its unsaturated matter would have exerted an attractive force on the fluid in the second body, and would have drawn it nearer to itself, producing an accumulation or redundance of fluid at the adjacent end, and a corresponding deficiency at the remote end; that is, the former would have been rendered positive, and the latter negative. All this is exactly conformable to observation.

The facts with regard to transference are easily explicable upon this hypothesis, and they arise from the destruction of the equilibrium of forces, which confined the fluid to a particular situation or mode of distribution. Indeed, there is hardly any fact that is explained on the hypothesis of two fluids which is not equally explicable on the Franklinian theory; and the explanations by the first are easily converted into those of the second by substituting the expressions of *positive* and *negative* for those of *vitreous* and *resinous electricities*. The principal advantage of Franklin's system is its superior simplicity. When viewed as a mere hypothesis, calculated to facilitate our comprehension of the phenomena and of their connections, it is a matter of indifference which we employ, since they will either of them answer the purpose. For the future, however, we shall more generally employ the Franklinian theory, on account of its greater convenience.

III. *Electrical Machines.* The essential parts of an instrument for procuring large supplies of electricity, for the purposes of experiment, are the electric, the rubber, the prime conductor, the insulator, and the machinery for setting the electric in motion. The electric, by the excitation of which the electricity is to be developed, may be made of various substances. Polished glass has, however, received the preference. Its form is that of a hollow cylinder, or of a flat circular plate, revolving upon a horizontal axis. The cushion is usually made of soft leather, generally basil skin, stuffed with hair or wool, so as to be as hard as the bottom of a chair, but yet sufficiently yielding to accommodate itself, without much pressure, to the surface of the glass to which it is applied The prime conductor is a cylindrical tube, each end terminating in a hemisphere. There is no advantage in its being made solid, for the electricity is only contained at the surfaces. It may be made of thin sheet brass, or copper, or tin, or of pasteboard covered with gold leaf or tin-foil. Care must be taken that its surface be free from all points and asperities; and the perforations which are made in it, and which should be about the size of a quill, for the purpose of attaching wires and other kinds of fixtures, should have their edges well rounded and smoothed off. In order to render the arrangement of these parts more intelligible, we will describe one of the simplest and best of the cylindric machines. The glass cylinder *a b*, *Fig.* 4, Plate I. *Electricity*, is from 8 to 16 inches in diameter, and from 1 to 2 feet long, supported, for the purpose of insulation, on two upright pillars of glass, which are fixed to a firm wooden stand. Two hollow metallic conductors, equal in length to the cylinder, and about one-fourth of its diameter, are placed parallel to it, one on each side, upon two insulating pillars of glass, which are cemented into two separate pieces of wood, that slide across the base so as to allow of their being brought within different distances from the cylinder. To one of these conductors the cushion is attached, which is of the same length with the conductor *c*. Its pressure against the cylinder is regulated by an adjusting screw adapted to the wooden base at *e*, on which the glass pillar that supports the conductor is fixed. From the upper edge of the cushion there proceeds a flap of thin oiled silk, *d*, which is sewed on the cushion about a quarter of an inch from its upper edge. It extends over the upper surface of the glass cylinder to within an inch of a row of metallic points, proceeding, like the teeth of a rake, from a horizontal rod, which is fixed to the adjacent side of the opposite conductor. The motion of the cylinder, which is given by a single handle or by a multiplying wheel, must always be given in the direction of the silk flap.

That part of the cushion which comes in contact with the glass cylinder should be coated with an amalgam of tin, zinc, and mercury, applied by means of hog's lard. The amalgam should be placed uniformly over the cushion, until level with the line formed by the seam which joins the silk flap to the face of the cushion. No amalgam should be placed over this line, nor on the silk flap; and it is even requisite to wipe the silk flap clean whenever the continued motion of the machine shall have soiled it by depositing dust or amalgam on its surface.

The best amalgam is formed by melting together one ounce of tin and two ounces of zinc, which are to be mixed, while fluid, with six ounces of mercury, and agitated in an iron or thick wooden box until cold. It is then to be reduced to very fine powder in a mortar, and mixed with a sufficient quantity of hog's lard to form it into a paste.

The mode in which the electrical machine just described acts will readily be understood. The friction of the cushion against the glass cylinder produces a transfer of electric fluid from the former to the latter; that is, the cushion becomes negatively and the glass positively electrified. The fluid, which thus adheres to the glass, is carried round by the revolution of the cylinder, and its escape is at first prevented by the silk flap which covers the cylinder, until it comes to the immediate vicinity of the metallic points, which, being placed at a small distance from the cylinder, absorb nearly the whole of the electricity as it passes near them, and transfers it to the prime conductor. Positive electricity is thus accumulated in the prime conductor, while the conductor connected with the

Fig. 1

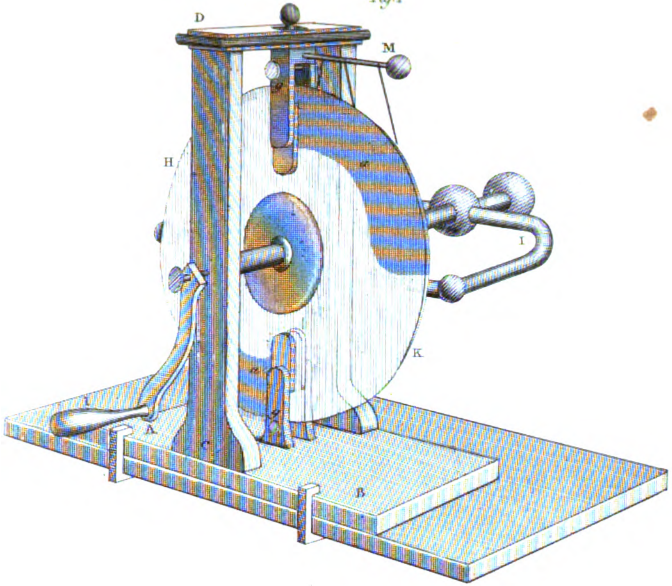


Fig. 5

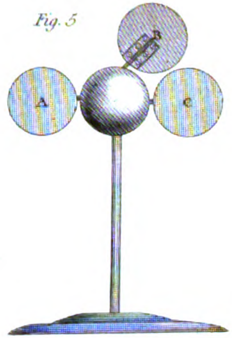


Fig. 4

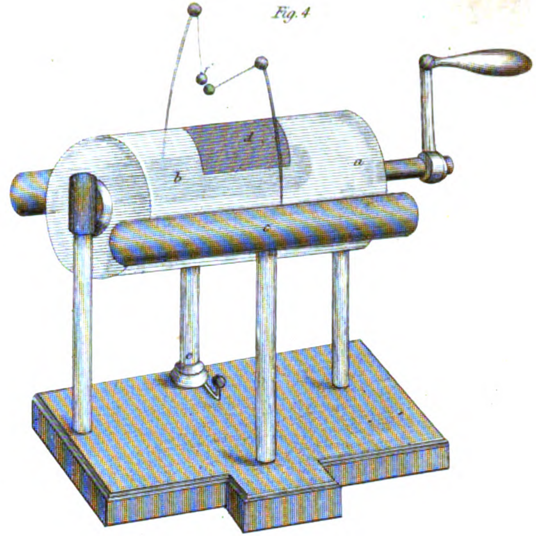


Fig. 6

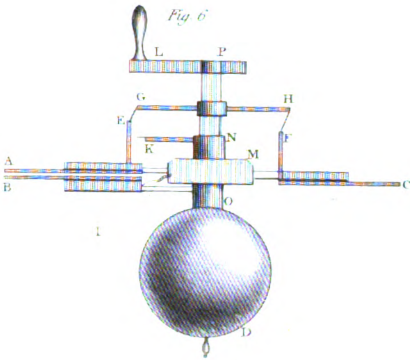


Fig. 3

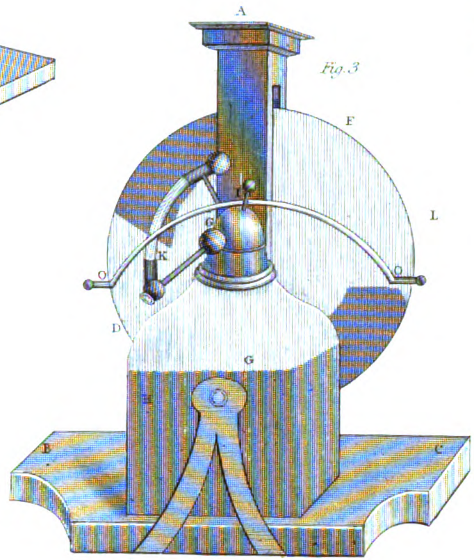
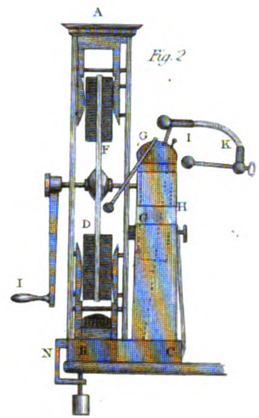


Fig. 2



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cushion, being deprived of this electricity, is negatively electrified, and light balls suspended by threads at *f* being oppositely electrified will attract each other. If both these conductors are insulated, this action will soon have reached its limit; for, when the cushion and its conductor have been exhausted of their fluid to a certain degree, they cannot, by the same force of excitation, supply any further quantity to the glass. In order to enable it to do so, we must replenish it, or restore to it a quantity equal to what it has lost. This is done by destroying the insulation of the cushion through the means of a metallic chain or wire, extending from it to the earth, which is the great reservoir of the electric fluid. The prime conductor will now be supplied with a constant stream of positive electricity. If it be our object, on the other hand, to accumulate negative electricity by the same instrument, we have only to insulate the conductor to which the cushion is attached, and to connect the prime conductor with the ground, in order to allow the fluid to escape from it as soon as it is collected from the cylinder. The fluid will thus continue to be drawn, without interruption, from the negative conductor, as it now meets with no impediment to its discharge on the opposite side of the machine.

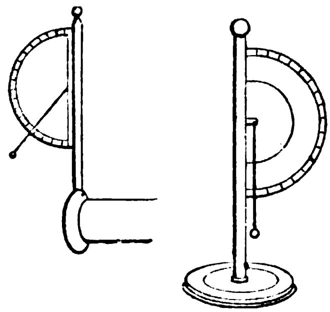
That the quantity of positive electricity produced in one conductor is exactly equal to that of the negative electricity in the other is proved by the fact, that, if the two conductors are connected by a wire, no signs of electricity are obtained in any of the conductors on turning the machine.

A person standing on a stool with glass legs is thereby insulated; and if, in this situation, he touch the prime conductor, either with his hand or through the medium of a metallic rod or chain, he may be considered as forming part of the same system of conductors. When the machine is worked, therefore, he will partake, with the conductor, of its charge of electricity, and sparks may be drawn from any part of his body by the knuckle of any other person who is in communication with the ground.

IV. The effect of electrical attraction and repulsion may now be exhibited much more distinctly with the aid of those considerable accumulations of electricity which we are enabled to form by the electrical machine. A pith ball, or a fragment of gold leaf, is very strongly and immediately attracted by the electrified conductor; and, the instant after it has come into contact with it, it is repelled; but it is now attracted by the other bodies in its neighbourhood, to which it communicates its own electricity, and then is again in a state to be influenced by the conductor, and to be again attracted; and this alternation of effects will continue as long as the conductor remains charged. This alternation of attractions and repulsions accompanying the transferring electricity by movable conductors is also illustrated by the motions of a ball suspended by a silk thread, and placed between two bells, of which the one is electrified and the other communicates with the ground. The alternate motion of the ball between the two bells will keep up a continual ringing. This amusing experiment has been applied to give notice of changes taking place in the electrical state of the atmosphere.

The mutual repulsion of bodies that are similarly electrified gives rise to many interesting experiments. A small figure in the shape of a human head, covered with hair, when placed upon the conductor and electrified, will exhibit the appearance of terror from the bristling up and divergence of the hair.

Advantage is taken of the repulsive property of electrified bodies for the construction of an instrument adapted to measure the intensity of the electricity they may contain. This instrument is called an *electrometer*. That invented by Henley consists of a slender rod of very light wood, serving as an index, terminated by a small pith ball, and suspended from the upper part of a stem of wood, which is fitted to a hole in the upper surface of the conductor. An ivory semicircle or quadrant is affixed to the stem, having its centre coinciding with the axis of motion of the rod, for the purpose of measuring the angle of deviation from the perpendicular, which the repulsion of the ball from the stem produces in the movable rod. The number of degrees which is described by the index affords some evidence of the quantity of electricity with which the apparatus is charged, though the instrument cannot be viewed as affording an exact measure of its intensity. Two of these are shown in the accompanying engraving; the first on the prime conductor of the machine, the other on a stand.



The *gold leaf electrometer* of Bennet, or rather *electroscope*, is a very delicate instrument, and is much employed for detecting the presence of electricity. It consists of two narrow slips of gold leaf, suspended parallel to each other in a glass cylinder (which secures them from disturbance by the air), and attached to the end of a small metallic tube, terminating above either in a flat surface of metal or a metallic ball. Two slips of tin-foil are pasted to the inside of the cylinder, on opposite sides, in a vertical position, and so placed as that the gold leaves may come in contact with these, when their mutual repulsion is sufficiently powerful to make them diverge to that extent. These slips of tin-foil terminate in the foot of the instrument, and thus are in communication with the earth. A very minute charge of electricity, communicated to the upper end of the tube, is immediately transmitted to the gold leaves, which are thus made to repel each other; but, if the repulsion is such as to make them strike against the tin-foil, their insulation ceases, and their electricity is carried off, and, becoming neutral, they resume their original position. We may here notice the electrometer invented by Coulomb, and called by him the *torsion balance*. It consists of a cylindrical glass jar, covered at the top by a circular glass plate, with a hole in its centre, through which descends, nearly to the bottom of the jar, a single fibre of the web of the silk-worm, with a needle of gum-lac or a piece of straw coated by sealing-wax, affixed to its lower extremity. The needle is terminated at one end by a small pith ball, and at the other by a disc of varnished paper, to serve as a counterpoise to the ball. The upper end of the silk fibre is attached to a kind of button, having a small index, and capable of

being turned round upon a circular plate divided into degrees. One side of the jar is perforated towards its bottom, to allow of the insertion of a short, horizontal bar, having a small metallic sphere at each of its ends, the one being within and the other upon the outside of the jar, and the former being so situated as just to allow the ball of the suspended needle to come in contact with it in the course of its revolution. By turning the button, or the index, the needle may be brought into this or any other required position with regard to the ball.

It is found by experiment that the angle of torsion of the silk fibre is, within a certain range of distance, very nearly in the direct ratio of the force which acts in producing the torsion; and therefore, if the two balls be placed in contact by turning the button, and then similarly electrified, the distance to which they are repelled by the angular motion of the suspended ball affords a measure of the repulsive force exerted. In like manner, the distance which the suspended ball is made to move, when it is attracted by the fixed ball, when the two have opposite electricities, gives accurate measures of the attractive forces.

V. It had long been observed that the quantity of electricity which bodies are capable of receiving does not follow the proportion of their bulk, but depends chiefly upon the extent of their surface. It was found, for example, that a metallic conductor, in the form of a globe or cylinder, contains just as much electricity when hollow as it does when solid, from which it was inferred that electricity does not extend throughout the mass of a body, but resides altogether at its surface. By the application of mathematical calculations to the theory, the most exact information with regard to the distribution of the electric fluid in bodies of different shapes has been obtained; and whenever a comparison has been instituted, even in cases of the most complicated kind, between the results of experiment and of theory, the most perfect agreement has been observed between them.

For the purpose of measuring the proportional quantities of electricity, with which different parts of the same or of different bodies are charged, no instrument is so well fitted as the balance of Coulomb. Such is its extreme sensibility, that a force only equal to the 270th of a grain is sufficient to make the needle perform an entire revolution; the 360th part of this force, therefore, or less than the 100,000th of a grain, is capable of being estimated by each degree of its angular motion.

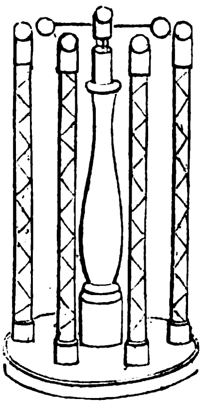
It would be inconsistent with the limits of the present article to go into a detail of the delicate methods of research adopted in the investigation of this subject. The following are among some of the most interesting results deduced from them. In a solid body, having the form of a perfect sphere, and charged with positive electricity, the whole of the fluid is, in consequence of the repulsion of its own particles, which is every where directed from the centre outwards, accumulated in a thin stratum, at the very surface of the sphere. If the body be charged with negative electricity, the deficiency of fluid will take place only in the superficial stratum of matter. If, instead of being spherical, the body have any other form, the electricity will be chiefly confined to the surface; and, if it have an elongated form, there will be a greater charge in the remoter parts than in those nearer to the middle.

This result of theory, respecting the limitation of electricity to the mere surface, is confirmed, in the most decisive manner, by the experiments of Coulomb. A conducting body, of a spheroidal shape, with small pits in various parts of its surface, half an inch in diameter, and one-tenth of an inch in depth, was electrified, and examined by the torsion balance. The bottoms of these pits afforded no indications of having received any electricity, while the even surface exhibited strong electrical excitement. We may conclude, both from theory and experiment, therefore, that although, strictly speaking, the electricity must reside within the substance of conducting bodies, it extends, in fact, to a depth so small as to be inappreciable by any known methods of observation.

The effect of an expansion of surface in lessening the intensity of electricity, while its absolute quantity remains the same, is illustrated by the following experiment: around an insulated cylinder, movable on an horizontal axis, and turned by an insulating handle, is wound a thin lamina of any metal, the end of which is semi circular, and has attached to it a silk thread. The whole apparatus communicates with an electrometer, formed of two linen threads, each terminating in a pith ball. On communicating a charge of electricity to the cylinder, the threads and balls of the electrometer attached to it diverge. Upon taking hold of the silk thread, and unrolling the metallic lamina from the cylinder, the balls gradually collapse, thus indicating a diminution in the intensity of electrical repulsion. But, on winding up the lamina, by turning the insulating handle, the electricity is restored, and the balls diverge to the same extent as before, allowance being made for the small dissipation of electricity, from the contact of the air during the experiment.

In the case of a long and slender lamina of conducting matter, charged with electricity, Coulomb found that its intensity continued nearly uniform, from the middle of the lamina to within a short distance from the ends; at that part it rapidly increased; and, at the very extremity, it became twice as much as at the middle part. He also found that in a cylinder 30 inches long, and 2 in diameter, the intensity of the electricity at the ends was to its intensity in the middle, or at any part more than 2 inches from the extremity, as 23 to 1. From which instances we infer that, if a conducting substance be drawn out into a point, the intensity of the electricity at that point will be exceedingly great, and that the point will accordingly absorb and draw into itself nearly the whole of the electricity that is contained in the body. This great concentration of electricity is found actually to take place in all points that project beyond the general surface. The pressure excited by the electric fluid against a non-conducting medium, such as the air, which opposes an obstacle to its escape, is in a ratio compounded of the repulsive force of its own particles at the surface of the stratum of fluid, and of the thickness of that stratum; but, as one of these elements is always proportional to the other, the total pressure must, in every point, be proportional to the square of the thickness. If this pressure be less than the resistance, or *coercive force* as it has been called, of the air, the electricity is retained; but, the moment it exceeds that force in any one point, the electricity suddenly escapes, just as a fluid confined in a vessel would rush out, if it were to burst open a hole in the side of a vessel.

The irruption of the electric fluid is marked by several very striking phenomena. A sharp snap is heard, accompanied by a vivid spark, and there are evidences of an intense heat being evolved in the line which the electricity takes. Its passage through a perfect conductor is unattended with light. Light appears only where there are obstacles in its path, by the interposition of imperfect conductors; and such is the velocity with which it is transmitted that the sparks appear to take place at the very same instant along the whole line of its course. Thus, if a row of small fragments of tin-foil be pasted, so as to be nearly in contact, on a piece of glass, and electricity be sent through them, by connecting one of its ends with the conductor of an electrical machine while the other end communicates with the ground, it will not be possible to detect any difference of time in the occurrence of the light in the different parts. If the tin-foil be arranged so as to represent a chain, it will appear luminous at each link, while conveying a charge of electricity.



A mode of showing a very beautiful electrical experiment is exhibited in the accompanying apparatus. It consists of a series of glass tubes, and a revolving wire with two knobs; and these, being made to rotate, give a series of sparks to the tinfoil on the different tubes, which thus become luminous.

The longest and most vivid sparks are obtained between two conductors having a rounded form, as may be exemplified in a common electrical machine, by presenting a metallic ball to that side of the prime conductor which is furthest from the cylinder of the machine; a spark is immediately seen, of considerable length, resembling a long streak of fire, extending from the conductor to the ball. Often, when the spark is very long, it is seen to have an angular or zigzag course, exactly like that of a flash of lightning. This irregularity is probably occasioned by the fluid darting obliquely in its course to minute conducting particles, as those of moisture, that are floating in the air, a little removed from the direct line of passage. Electrical light differs but little from the light obtained from other sources. Its brilliancy depends upon its real intensity. This fact has lately been proved by Mr. Wheatstone. When dry wood is employed, it appears in the form of faint red streams; but metals afford a light of greater brilliancy. Its colour is subject to variations from a great number of different circumstances. Sparks passed through balls of wood or ivory are of a crimson colour; but this depends upon their position with regard to the surface.

Electric sparks, passing from one polished metallic surface to another, are white; but, if the finger be presented to an electrified conductor, the sparks obtained are violet. They are green when taken from the surface of silvered leather; yellow when taken from finely powdered charcoal; and of a purple colour when taken from the greater number of imperfect conductors.

In exceedingly rarefied air, the colour of the spark is green; in denser air, it acquires a blue tint, and passes to a violet and purple as the condensation of the air is increased. In making these experiments, it is found that in proportion as the medium is more rare its conducting power increases, and a smaller intensity of electricity is required for the production of light. In the ordinary vacuum of the air-pump, the passage of electricity is rendered sensible by streams or columns of diffused light occasionally varying in their breadth and intensity, and exhibiting movements which give them a marked resemblance to the coruscations of the aurora borealis.

It was at first imagined that the light which appears during the passage of electricity was actually the electric fluid itself, become luminous from its high degree of accumulation. But, since we know that common atmospheric air becomes luminous by violent compression, and we must also presume that electricity exerts a very sudden and powerful pressure upon the air by its passage through that resisting medium, we are certainly justified in drawing the inference that the same phenomena proceed, in both cases, from the same cause. The sound which accompanies the various modes of transference is subject to modifications dependent upon the degree and suddenness of the impulses given to the air. The full, short, and undivided spark is attended with a loud explosion; the more lengthened spark with a sharper snap, which becomes more broken and rattling in proportion to the distance it has to traverse.

The great increase of intensity which the electric fluid acquires at the extremities of all elongated conducting bodies, and especially the indefinite augmentation of this intensity at the apex of all projecting points, has been alluded to above. This intensity will necessarily be accompanied with a powerful disposition in the fluid to escape—a circumstance which furnishes a natural and exact explanation of the rapid dissipation of electricity which takes place from all bodies of a slender and pointed form.

The illustration of these positions is seen in bringing metallic rods of different forms near the prime conductor of a machine charged with either species of electricity, the conductor being furnished with a pair of pith balls, suspended by a fine wire, whose divergence indicates the presence and degree of the electricity in the conductor: if the metallic rod have a bell at the end which is brought near the charged conductor, the pith balls will be but slightly affected; whereas, if it terminate in a sharp point, and the point be presented to the conductor at the same distance as the ball was in the former case, the divergence of the balls will immediately cease, showing that the electrical charge has wholly disappeared.

Currents of air always accompany the discharge of electricity from pointed bodies; for each particle of air, as soon as it has received its electricity from the point, is immediately repelled by the body. Many amusing experiments are founded on this principle. Let two cross wires, bent at right angles near the ends, which terminate in points, and pointing in a similar direction with respect to the axis, be supported at their centre upon a fine point, and electrified by being placed upon the prime conductor of a machine; each of the points will give off a stream of electricity, and the wires will revolve backward with considerable rapidity. An apparatus consisting of wires terminating in points, and having balls annexed to them, to represent the planets, may be constructed so as to re-

volve when electrified, and thus to imitate the planetary motions. Such an apparatus has been called an *electrical orrery*, and is shown in *Plate* 2, ELECTRICITY.

When the transfer of electricity takes place between smooth surfaces of a certain extent, no difference can be perceived in the nature and appearance of the spark, whichever be the position of the negative surface. But, in the passage of electricity through points, the effect is considerably modified by the species of electricity with which the bodies are charged; or, in other words, by the direction in which the fluid moves. When the electric fluid is escaping out of a pointed conductor, the luminous appearance is that of diverging streams, forming what is termed a *pencil of light*, and resembling the filaments of a brush. When, on the contrary, the electric fluid is entering into the pointed body, the light is much more concentrated at the point itself, having a resemblance to a star, in which if any streams appear they are disposed like radii, and equally so in all directions. This difference in these two appearances may be employed, on many occasions, as a useful criterion of the species of electricity, at least, which is passing from one conductor to another, if not of the absolute direction of its motion. For, if a needle be presented to an electrified body, the appearance of a star on the needle will show that the electricity of that body is positive; while, on the contrary, a luminous brush on the needle will indicate that the body is negative.

These observations seem to indicate the emanation of some material fluid from the positive and its reception by the negative point. It has, accordingly, been urged as an argument in favour of the Franklinian theory. The diverging lines on one side, and their inflections on the other, represent exactly the paths of particles flowing out as from a pipe, and urged forward by a force which gives them such a projectile velocity as to prevent their spreading out beyond a certain distance from the direct line of projection. But this very velocity will carry the particles that happen to have deviated most somewhat beyond the point to which they are attracted; while the attraction to this latter point will tend to deflect them from the line of their path, and gradually turn them back, so that they will arrive at the point of attraction by very different paths, and some even by a retrograde motion. Hence, while, in the former case, they form a diverging cone of rays, in the latter they must be distributed on all sides of the point, like the rays of a star.

VI. Active electricity, existing in any substance, tends always to induce the opposite electrical state in the bodies that are near it. Now, it is impossible to induce one electrical state in any body without, at the same time, producing the opposite state in the same body, or in the one which is immediately contiguous. It follows, therefore, that if the bodies subjected to the inductive influence are non-conductors, although the tendency to produce the opposite electricity exists, yet, in consequence of the immobility of the fluid, it can produce no visible change.

In proportion as the body opposes less resistance to the passage of electricity, the operation of the disturbing force becomes sensible. For example, in the case of a positively charged electric, acting by induction on an insulated conducting body, the redundant fluid in the former must tend to repel all the fluid contained in the latter; a portion of this fluid must, therefore, be driven from the side adjacent to the first body, towards the remoter side. The adjacent side will thus be rendered negative; the remoter side positive. But this will take place to a certain extent only; for there is a limit at which the repulsion of the fluid accumulated at the remote end will just balance the repulsion of the fluid in the electric, added to the attraction of the under-saturated matter, in the near end; and, when the limit has been attained, the flow of electric fluid from the near to the remote end of the body will cease, and an equilibrium will be established. Experiment fully confirms this theory, as may be seen by bringing a cylinder of metal of some length, with rounded ends, near an electrified globe of glass, taking care that it be not sufficiently near to receive any quantity of electricity by transference.

By means of the electrometer of Coulomb, we perceive that the part of the conductor nearest to the electric is negative, and the part most remote is positive; while, about the middle of the cylinder, the body is in a neutral state. The electricity is found to diminish as we proceed from either extremity towards this point of neutrality.

These remarkable effects are solely the result of the action of electricity at a distance; for they take place in an equal degree whatever non-conducting substance may be interposed between the bodies exerting this influence on one another. But in an experiment where the acting body, instead of being an electric, is a conducting body, the electrical state which the globe induces on the cylinder must re-act upon its own electricity.

The negative electricity, that is, the under-saturated matter at the nearer end of the cylinder, must exert a tendency to induce positive electricity in the globe, and more especially upon the side next the cylinder; that is, it will tend, by its attraction for the fluid, to draw it to that side, and thus render it still more highly positive than it was before. This can only be done at the expense of the other side, from which the fluid must be taken, and which is therefore rendered less charged with fluid, that is, less positive, than before. But this new distribution of the electric fluid in the globe, by increasing the positive state of the side next the cylinder, tends to augment its inductive influence on the fluid in the cylinder, that is, to drive an additional quantity of fluid from the negative to the positive end. This must be followed in turn by a corresponding reaction on the globe, and so on, constituting a series of smaller adjustments, until a perfect equilibrium is established in every part. This reasoning is fully established by experiment. All that is required for its illustration is simply to furnish the metallic globe, insulated and charged with positive electricity, with electroscopes upon its opposite surfaces. No sooner do we bring near to it a conducting body than the balls of the electroscope, at the side most distant from that body, begin to collapse, while those at the nearer side diverge to a greater degree than before; thus showing the nature of the reflex operation of the induced electricity of the conductor upon the body from which the induction originated.

In all the changes thus alluded to, there has been no transfer of electricity from either of the bodies to the other, as is most satisfactorily proved by the circumstance that the mere removal of the

ELECTRICITY.

Fig. 1.

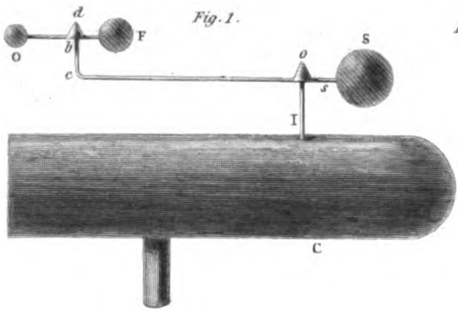


Fig. 2.

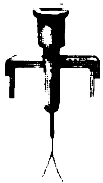
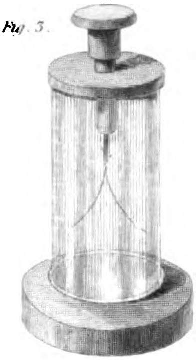


Fig. 4.

Fig. 3.



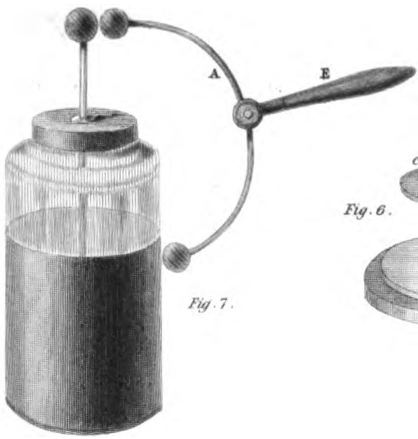


Fig. 7.

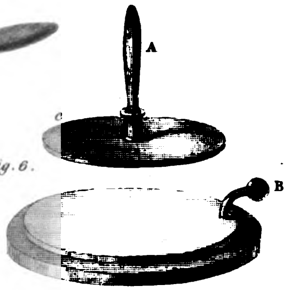


Fig. 6.

Fig. 5.

Fig. 8.

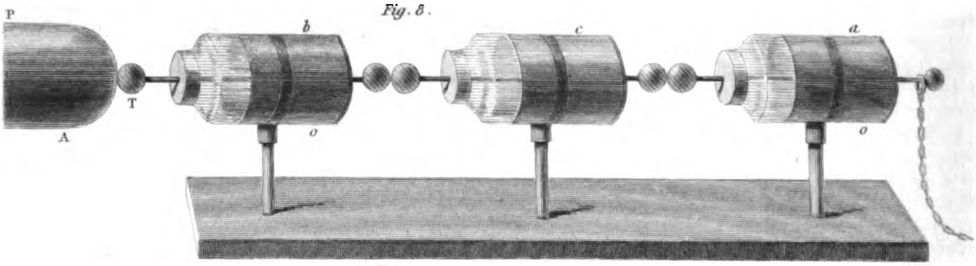
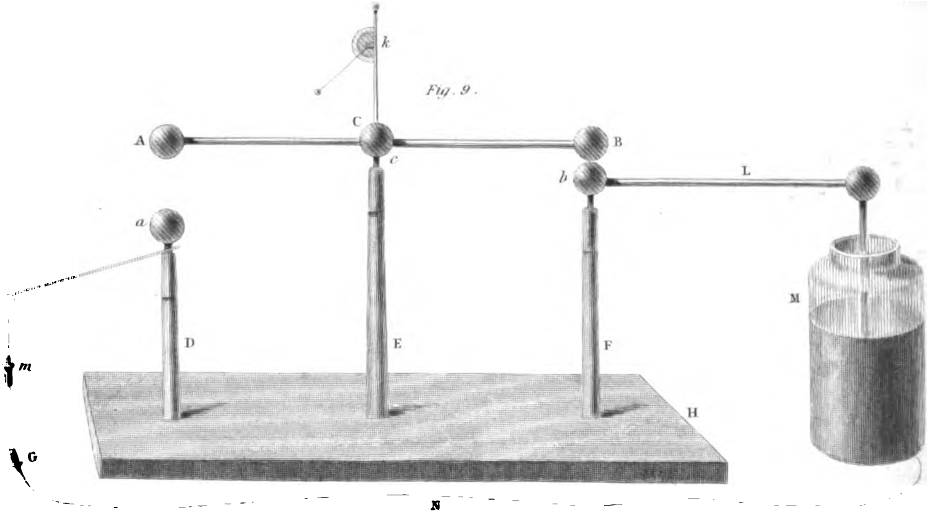


Fig. 9.



bodies to a distance from one another is sufficient to restore each of them to its original state. The globe remains as perfectly electrified as before; the cylinder returns to its condition of perfect neutrality; and the experiment may be repeated as often as we please, without any variation in the phenomena. This would not be the case, however, if the cylinder were divided in the middle, and one or both of the parts were removed separately, while they still remained under the influence of the globe. The return of the electric fluid from the positive to the negative end being thus prevented, each part will retain, after its separation, the electricity which had been induced upon it; the nearer portion will remain negative, the remoter one positive. If the division had been in three parts, the middle part only would have been neutral.

It is found by experiment that the effects of induction on a conductor are augmented by increasing its length; and they become as great as possible by placing the conductor in communication with the earth, which carries off all the fluid the electrified body is capable of expelling from the nearest end. A conductor under the influence of induction, between which and the earth a communication has been made, by touching the remote end with a metallic rod held in the hand, possesses but one kind of electricity, namely, the one opposite to that of the electrified body which is acting upon it. The part touched is brought into a state in which it appears to be neutral, as long as it remains in the vicinity of the electrified body; but it really contains less fluid than its natural share; and this will immediately become apparent if the conductor that has been touched be again insulated, and then removed from the influence of the body producing the induction.

This peculiar condition of a body, in which its parts are really undercharged or overcharged with fluid, although, from the action of electric forces derived from bodies in its vicinity, a state of equilibrium is established, and no visible effect results, has been denominated by Biot *disguised electricity*. We have hitherto supposed the acting body to be positively electrified; but precisely the same effects would happen with regard to the degree, although opposite as to the species of electricity, if it had been negatively electrified. Our knowledge of the induction of electricity enables us to understand why bodies between which it takes place should attract one another. For the action of the adjacent sides which are brought into opposite electrical states is greater than the action of those sides which are in the same electrical states, and which are more distant; hence the attractive force always exceeds the repulsive.

The most convenient mode of obtaining an accumulation of electricity arising from induction is by the employment of coated glass, that is, of a plate of glass on each side of which is pasted a sheet or coating of tin-foil. Care must be taken to leave a sufficient margin of glass uncovered with the metal for preventing the transfer of electricity from one coating to the other, round the edge of the glass; and all sharp angles or ragged edges in the coatings should be avoided, as they have a great tendency to dissipate the charge.

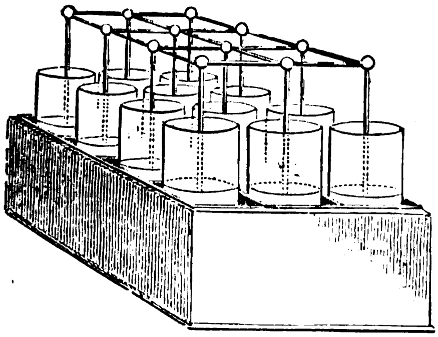
The form of coated glass best adapted to experiments is that of a cylindric jar; this is coated, within and without, nearly to the top. The cover consists of baked wood, and is inserted with sealing wax, to exclude moisture and dust. A metallic rod, rising two or three inches above the jar, and terminated at the top in a brass knob, is made to descend through the cover till it touches the interior coating. The name of the *Leyden phial*, or *jar*, is applied to this instrument. It is used in the following manner: the outer coating being made to communicate with the ground, by holding it in the hand, the knob of the jar is presented to the prime conductor when the machine is in motion; a succession of sparks will pass between them, while, at the same time, nearly an equal quantity of electricity will be passing out from the exterior coating, through the body of the person who holds it, to the ground. The jar, on being removed, is said to be charged; and if a communication is made between the two coatings, by a metallic wire, extending from the external one to the knob, the electric fluid which was accumulated in the positive coating rushes, with a sudden and violent impetus, along the conductor, and passes into the negative coating; thus at once restoring an almost complete equilibrium. This sudden transfer of a large quantity of accumulated electricity is a real explosion; and it gives rise to a vivid flash of light, corresponding in intensity to the magnitude of the charge. The effect of its transmission is much greater than that of the simple charge of the prime conductor of the machine; and it imparts a sensation, when passing through any part of the body, of a peculiar kind, which is called the *electric shock*.

The arrangement of the parts in a Leyden jar, as well as the mode of charging and discharging it, is shown in several figures of *Plate* 2, ELECTRICITY. It may be proper to state, that *talc* or *mica* is as well fitted for electrical purposes as glass; and, owing to the extreme thinness of its *laminæ*, it is more readily put in operation. It is also more durable.

In the construction of the Leyden jar, the thickness of the glass is an important consideration. The thinner the glass the greater will be the power of taking a charge; but the power of retaining it will be less, on account of the diminished resistance which the glass will oppose to the electricity through it. If the charge be higher than what the jar will bear, the glass will be broken by the violence with which the electric fluid forces a passage through its substance. Another limit to the charge which a jar is capable of retaining arises from the liability of the electricity to pass from one coating to the other, round the edges of the glass. The deposition of moisture, also, on the glass, will occasion a spontaneous discharge, since it forms a chain of conducting particles, in the very line which the electricity has a tendency to take. Hence, in order to preserve the uncoated part of the glass in as dry a state as possible, it is usually covered with a layer of sealing-wax, or some other resinous varnish.

By uniting together a sufficient number of jars, we are able to accumulate an enormous quantity of electricity: for this purpose, all the interior coatings of the jars must be made to communicate by metallic rods, and a similar union must be established among the exterior coatings. When thus arranged, the whole series may be charged, as if they formed but one jar; and the whole of the accumulated electricity may be transferred from one system of coatings to the other, by a general and simultaneous discharge.

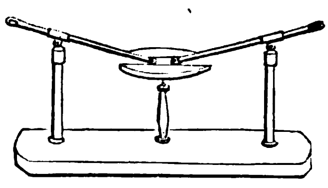
Such a combination of jars is called an *electrical battery*.



An arrangement of this description is represented above, in which twelve jars are united in one box, and the whole series connected together by wires and balls.

For the purpose of making a direct communication between the inner and outer coating of a jar or battery, by which a discharge is effected, an instrument called the *discharging rod* is employed. It consists of two bent metallic rods, terminated at one end by brass balls, and connected at the other by a joint, which is fixed to the end of a glass handle, and which, acting like a pair of compasses, allows of the balls being separated at different distances. When opened to the proper degree, one of the balls is made to touch the exterior coating, and the other ball is then quickly brought into contact with the knob of the jar, and thus a discharge is effected, while the glass handle secures the person holding it from the effects of the shock.

If we wish to send the whole charge of electricity through any particular substance which may be the subject of experiment, we must so arrange the connecting conductors as that the substance shall form a necessary part of the *circuit of the electricity*, as it is termed. With this view, we must place it between two good conductors, one of which is in communication with the outer coating; and the circuit may then be completed by connecting the other conductor with the inner coating, by means of a discharging rod, to one branch of which, if necessary, a flexible chain may be added. A very useful apparatus of this kind is shown beneath.



VII. In forming arrangements for directing the passage of accumulated electricity, it should be borne in mind that the electric fluid will, on these occasions, always pass through the best conductors, although they may be more circuitous, in preference to those which are more direct but have inferior conducting power; and it must also be recollected that, when different paths are open for its transmission along conductors of equal power, the electricity will always take that which is the shortest. Thus, if a person, holding a wire between his hands, discharges a jar by means of it, the whole of the fluid will pass through the wire, without affecting him; but, if a piece of dry wood be substituted for the wire, he will feel a shock; for, the wood being a worse conductor than his own body, the charge will pass through the latter, as being the easier, although the longer circuit. During its transit through the human body, in like manner, the shock is felt only in the parts situated in the direct line of communication; and if the charge be made to pass through a number of persons, who take one another by the hand, and form part of the circuit between the inner and outer coatings of the jar, each will feel the electric shock in the same manner and at the same instant; the sensation reaching from hand to hand, directly across the breast. By varying the points of contact, however, the shock may be made to pass in other directions, and may either be confined to a small part of a limb, or be made to traverse the whole length of the body, from head to foot.

By accurate experiments it appears that the force of the electric shock is weakened, i. e. its effects are diminished, by employing a conductor of great length for making the discharge. But it is difficult to assign a limit to the number of persons through whom even a small charge of electricity may be sent, so that all shall experience the shock, or to the distance along which it may be conveyed by good conductors. The abbé Nollet passed an electrical shock through 180 of the French guards, in the presence of the king; and the sensation was felt at the same moment by all the persons composing the circuit.

An experiment was made near London, at a time when the ground was remarkably dry, to ascertain if any loss of time accompanied the passage of the fluid, when transmitted through considerable distances. It was made to perform a circuit of four miles; being conducted for two miles along wires supported on baked sticks, and for the remaining distance through the dry ground. As far as could be ascertained, by the most careful observation, the time in which the discharge was transmitted along that immense circuit was perfectly instantaneous. It may be proper to state that Mr. Wheatstone has lately invented a very ingenious instrument, which possesses the power of measuring the velocity with which electricity is transmitted.

A retardation in the passage of electricity does take place if the conductor be not of a sufficient size; and when this is the case, as well as in those instances where the conductor is not a good one, the discharge will not be effected so instantaneously or so completely. Under these circumstances, also, there is a tendency in the fluid to diverge from the direct line of its course, and to fly off to different objects in the vicinity, as is often exemplified in the case of lightning, which, on striking a building, is apt to take a very irregular and seemingly capricious route, darting towards conducting bodies which may happen to attract it, although at some distance from the immediate direction it was pursuing. The motion of electricity through perfect conductors is attended with no perceptible alteration in the mechanical properties of the conducting bodies, provided they be of sufficient size for the charge of the electric fluid transmitted. On the contrary, very considerable effects are produced when a powerful charge is sent through a wire which is too small to allow the whole quantity to pass with perfect freedom, or

through an imperfect conductor, though of a large size, as is proved when a tree is struck by lightning. A piece of dry writing paper, as well as pieces of dry, porous wood, are easily torn in pieces by an electric charge.

There is a mode of charging a series of jars, which in small batteries might be practised with advantage. A series of three jars is shown at *Fig.* 8, *Plate* 2. The electricity is supplied by the prime conductor, P, which passes from the end, A, to the inner coating of the jar T. The jars are supported by the rings and stands *a b c*. The external surface of the jar *a*, to become negatively electrical, must discharge a portion of its electricity to the inner coating *q*, of the next jar, and so on through the series. If these be afterwards separated, and the whole of the balls united together, a perfect battery must result.

The simple bent discharging rod, for restoring the electrical equilibrium without the operator receiving the charge of the jar, is shown at *Fig.* 7, *Plate* 2, in which E represents the insulating handle, and A the ring of brass reaching from the ball to the external coating.

VIII. Electricity exerts a most extensive and important influence in effecting changes in the temperature and chemical composition of bodies. The ignition and fusion of metals by the electric charge, are phenomena which have been long observed. Thus, by passing a strong charge through slender iron wires, or the finest flatted steel, called *pendulum wire*, they are ignited, and partly melted into globules, and at the same time partially oxidated. If a slip of gold or silver leaf be placed on white paper, and a strong shock passed through it, the metal will disappear with a bright flash; and the impulse with which its particles are driven against the paper will produce a permanent stain of a purple or gray colour. The colours produced in this way have been applied to impress letters or ornamental devices on silk and on paper. For this purpose, the outline of the required figure should be first traced on thick drawing paper, and afterwards cut out in the manner of stencil plates. The drawing paper is then placed on the silk or paper intended to be marked; a leaf of gold is laid upon it, and a card over that; the whole is then placed in a press or under a weight, and a charge from a battery sent through the gold leaf. The stain is confined, by the interposition of the drawing paper, to the limit of the design, and in this way a profile, a flower, or any other outline figure, may be very neatly impressed.

There is an instrument contrived by the late Mr. Cuthbertson, which is well fitted for exhibiting this and other effects of a similar character. It is represented at *Fig.* 9, *Plate* 2, Electricity, and consists of a base, H, supporting an upright pillar of glass, E. The beam, A B, revolves on an axis, or fulcrum, C, and above all is placed the electrometer, *k*. A Leyden jar is shown at M, provided with a communicating wire, *m*, which unites it with the ball *a*, supported by the glass leg, D. Another glass column, F, is provided with a brass ball, *b*, and rod, L, leading to the interior of the jar. If we now suppose the object of the experimentalist be to strike a figure or flower by electricity, it is only necessary to make it part of the circuit, and when the jar is charged so high that its repulsive power will cause the ball B, to ascend, a wire concealed within keeps up the communication with *b*, and the other extremity of the balance, A, by dropping to *a*, makes the communication complete. Inflammable bodies may also be fired by the tubes shown at *m*.

The heat evolved by electricity, like most other of its effects, is in proportion to the resistances opposed to its passage. A rod of wood, of considerable thickness, being made part of the circuit, has its temperature sensibly raised by a very few discharges. Most combustible bodies are capable of being inflamed by electricity. Thus alcohol, ether, camphor, powdered resin, phosphorus, or gunpowder may be set on fire. And the sparks taken from a piece of ice are as capable of inflaming bodies as those from a piece of red-hot iron. The oxidation of metals, through which accumulated electricity has been passed, is rather to be ascribed to the tendency which they are known to possess of combining with the oxygen of the atmosphere when heated, than to any peculiar agency of electricity. A reverse process, however, is found to attend electrical discharges through metallic oxides, extricating their oxygen, and restoring them to their metallic state.

When a succession of electric discharges from a powerful electric machine are sent through water, a decomposition of that fluid takes place, and it is resolved into its two elements of oxygen and hydrogen, which immediately assume the gaseous form. When this experiment is conducted in a suitable apparatus, and a shock is transmitted through the mixed gases thus obtained, they are instantly kindled; a reunion of the elements takes place; and precisely the same quantity of water is reproduced as was decomposed to furnish the gases.

It may appear somewhat paradoxical that the same agent should, in the course of the same experiment, produce at one time decomposition, and at another combination, of the same elements. The simplest way of reconciling this apparent discordance, is to suppose that the combination of the gases is the effect of the heat evolved during its forcible transit through an aeriform fluid that opposes considerable resistance to its passage; while the decomposition of the liquid is the direct consequence of the agency of electricity in its chemical character, when not interfered with by heat.

When a solution of sulphate of copper is subjected to the action of electricity by means of slender conducting wires terminating in the vessel containing the solution, the copper is revived, or precipitated in a metallic state, around the negative wire; but, upon reversing the direction of the current of electricity, so that the same wire now becomes positively electrified, the copper which has collected around it is redissolved, and a similar deposit takes place on the opposite wire, which now becomes the negative one. Similar experiments, made with other metallic solutions, are attended with similar results; and solutions of neutral salts with alkaline and earthy bases obey the same law, being separated into their constituent parts, the ingredient containing oxygen always appearing at the positive wire, and the base at the negative wire; but as these are a class of effects which have been more particularly investigated by that mode of agency denominated *galvanism*, we shall reserve a more full account of them for that article.

IX. Having seen the effects of electricity on inanimate matter, we now proceed to describe the

agency it exerts over living bodies. Its passage through living plants immediately destroys the vitality of the parts through which it passes. A very small shock, sent through the stem of a balsam, causes its leaves to droop in a few minutes, and finally extinguishes its vitality. The approach of an electrified conductor to the sensitive plant (*mimoso pudica*) produces no effect upon it; but when sparks are taken from it, the leaves collapse, just as they are accustomed to do from concussions of a mechanical nature.

When the energetic effects of the shock from the Leyden jar upon the animal system were first made known, high expectations were raised that electricity would prove a remedial agent of extrordinary power. It was supposed that, as a stimulant, it would have many advantages over other remedies; for it can be administered in various degrees of intensity, which may be regulated with great exactness; and its application can be directed especially to the organ we wish to affect. Accordingly, we find, at one period, it was employed in a great number of cases; but at present it is confined to a very few; such as palsy, contractions of the limbs, rheumatism, St. Vitus's dance, some kinds of deafness, and impaired vision.

A very good electrical machine for medical purposes is represented at *Figs.* 2 *and* 3, *Plate* 1, Electricity. An end view of the machine is given in *Fig.* 2, and a front view at *Fig.* 3. F represents the plate, and A the frame of the machine. The handle is shown at I, and the prime conductor at O. H G, is the jar for communicating shocks to the patient, the amount being regulated by the discharger K. The whole machine is held down to the table by the clamp N, which, resting on the board B C, ensures stability to the whole.

There is another form of the electrical machine which is much used in this country. It consists of a plate of glass, placed vertically, and is represented at *Fig.* 1, *Plate* 1, of Electricity. The apparatus is supported by the mahogany base A A, provided with uprights, C, supporting a cross plate at D. The plate H K is pressed by the cushions, *g g*, which, with the rod M, also support the flaps of silk, *a a*. The prime conductor proceeds from the front of the machine, and is placed horizontally at I. Directly we give motion to the plate, the electricity is excited by the friction of the rubbers, and, being collected by the points in the prime conductor, serves to charge jars and perform a variety of amusing experiments.

Although the effects of ordinary shocks upon living animals are familiar to most persons, still a short account of these shocks, as they have been administered out of the common course may not be uninteresting. If a person who is standing receive a charge through the spine, he loses his power over the muscles to such a degree, that he either drops on his knees, or falls prostrate on the ground. A strong charge passed through the head gives the sensation of a violent but universal blow, and is followed by a transient loss of memory and indistinctness of vision. If the diaphragm be included in the circuit of a coated surface of two feet in extent, fully charged, the sudden contraction of the muscles of respiration will act so violently upon the air in the lungs, as to occasion a loud and involuntary shout; but if the charge be small, a fit of convulsive laughter is induced, producing a most ludicrous scene to the by-stander. Small animals, such as mice and sparrows, are instantly killed by a shock from 30 square inches of glass.

X. There are several mineral bodies, which, from being in a neutral state at ordinary temperatures, acquire electricity simply by being heated or cooled. This property is confined to crystallized minerals; and of these the most remarkable are the tourmaline and boracite. In the former of these, it is best observed in the regularly terminated crystals. When one of these is heated from 100° to 212° Fahr. the extremity terminated by the greatest number of planes becomes charged with positive electricity, while the other extremity is negative. When the crystal is of considerable size, flashes of light may be seen along its surface.

A large number of substances become electrified on passing from the liquid to the solid form. This happens to sulphur, gum-lac, bees-wax, and, in general, all resinous bodies. The conversion of bodies into the state of vapour, as well as the condensation of vapour, is generally attended by some alteration of their electrical condition. Thus, if a red-hot platina crucible be placed upon the gold leaf electrometer, and water be dropped into it, at the moment the vapour rises, the leaves of the electrometer diverge with negative electricity.

Electricity is evolved by the contact of different metals. Thus, if two discs, the one of copper, the other of zinc, rather more than two inches in diameter, and furnished with insulating handles, be brought into contact, and then separated and examined by an electroscope, the copper disc is found to be charged with negative, and the zinc disc with positive electricity. While the contact of the metals is preserved, neither of them gives any indication of its electrical state, the electricity being disguised until the separation takes place. This observation has an important relation to the theory of that mode of electrical excitement called *galvanism*, under which head it will be resumed.

There are some bodies which are rendered electrical by pressure. Thus, if a crystal of calcareous spar or arragonite be pressed for a few moments between the fingers, it exhibits a decided attraction. The same thing happens with regard to cork, paper, and wood. Many mineral substances, when reduced to powder, exhibit electricity, if made to fall upon an insulated metallic plate, a mode of excitation which is to be considered as a species of friction.

The most important circumstance in this inquiry is the connection between electricity and the chemical properties of matter, first pointed out by Sir H. Davy. Most of the substances that act distinctly upon each other electrically, are likewise such as act chemically, when their particles have freedom of motion. This is the case with the different metals, with sulphur and the metals, with acids and the alkaline substances. Of two metals in contact, the one which has the greatest chemical attraction for oxygen acquires positive electricity, and the other the negative.

XI. The resemblance between the electric spark, and more especially the explosive discharge of the Leyden jar, and atmospheric lightning and thunder, struck the mind of Doctor Franklin with so much force, that he was determined, if possible, to verify their identity by experiment.

Having constructed a kite, by stretching a large silk handkerchief over two sticks in the form of a cross, on the appearance of an approaching storm,

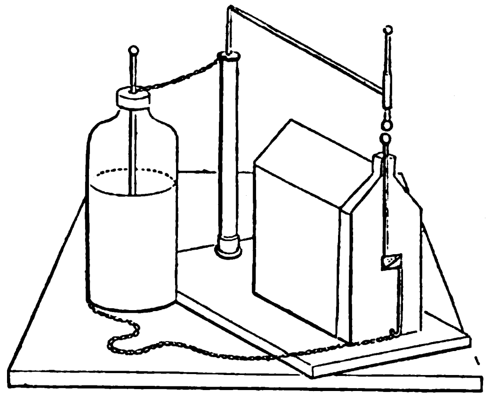
he went into a field in the vicinity of Philadelphia, and raised it, taking care to insulate it by a silken cord attached to a key, with which the hempen string terminated. No sooner had a dense cloud, apparently charged with lightning, passed over the spot on which he stood, than his attention was arrested by the bristling up of some loose fibres on the hempen string: he immediately presented his knuckle to the key, and received an electric spark. The rain now fell in torrents, and, wetting the string, rendered it conducting in its whole length; so that electric sparks were now collected from it in great abundance.

This celebrated experiment was made in June, 1752; and although the same idea which led Franklin to institute it had occurred to other philosophers, yet to him belongs, exclusively, the credit of the discovery. The discovery of Franklin immediately engaged the attention of European philosophers; one of whom, professor Richmann, of St. Petersburg, fell a victim to his attempt to draw down the electric fluid from the clouds. He had constructed an apparatus for observations on atmospherical electricity, and was attending a meeting of the Academy of Sciences, when the sound of distant thunder caught his ear. He immediately hastened home, taking with him his engraver, Sokolow, in order that he might delineate the appearances that should present themselves. While intent upon examining the electrometer, a large globe of fire flashed from the conducting rod, which was insulated, to the head of Richmann, and, passing through his body, instantly deprived him of life. A red spot was found on his forehead, where the electricity had entered; his shoe was burst open, and part of his clothes singed. His companion was struck down, and remained senseless for some time; the door-case of the room was split, and the door itself torn off its hinges.

The atmosphere is very generally in an electrical state. This is ascertained by employing a metallic rod, insulated at its lower end, elevated at some height above the ground, and communicating with an electroscope. In order to collect the electricity of the higher regions of the air, a kite may be raised, in the string of which a slender metallic wire should be interwoven. The atmosphere is almost invariably found to be positively electrified; and its electricity is stronger in the winter than in the summer, and during the day than in the night. From the time of sunrise, it increases for two or three hours, and then decreases towards the middle of the day, being generally the weakest between noon and four o'clock. As the sun declines, its intensity is again augmented, till about the time of sunset, after which it diminishes, and continues feeble during the night.

In cloudy weather, the electrical state of the atmosphere is much more uncertain; and when there are several strata of clouds, moving in different directions, it is subject to great and rapid variations, changing backwards and forwards in the course of a very few minutes. On the first appearance of fog, rain, snow, hail, or sleet, the electricity of the air is generally negative, and often highly so; but it afterwards undergoes frequent transitions to opposite states. On the approach of a thunder-storm, these alternations of the electric condition of the air succeed one another with remarkable rapidity. Strong sparks are sent out in great abundance from the conductor; and it becomes dangerous to prosecute experiments with it in its insulated state. Thunder is merely the noise produced by the motion of the lightning.

The mode of protecting buildings from the effects of lighting will be best shown by a diagram.



It represents a small wooden model of a house, from the top of which a rod descends attached to a chain passing to the external coating of a Leyden jar. A similar chain connects the internal coating with a metal rod supported by a glass pillar. If we now suppose the jar to be charged by the action of a machine, the upper rod will represent a cloud positively electrified, and if no break occurs in the conductor the electrical equilibrium will be restored. In the figure a small interruption occurs in the circuit, and at that point an explosion happens, so that the brick is thrown out. Models of this description are sometimes provided with a receptacle for holding powder or other inflammable matter, which is ignited by the passage of the electric fluid.

The protection of buildings from the destructive effects of lightning is the most important practical application of the theory of electricity. The conductors, for this purpose, should be formed of metallic rods, pointed at the upper extremity, and placed so as to project a few feet above the highest part of the building they are intended to secure; they should be continued without interruption till they descend into the ground below the foundation of the house. Copper is preferable to iron as the material for their construction, being less liable to destruction by rust, or by fusion, and possessing also a greater conducting power. The size of the rods should be from half an inch to an inch in diameter, and the point should be gilt, or made of platina, that it may be more effectually preserved from corrosion.

An important condition in the protecting conductor is, that no interruption should exist in its continuity from top to bottom; and advantage will result from connecting together by strips of metal all the leaden water-pipes, or other considerable masses of metal in or about the building, so as to form one continuous system of conductors, for carrying the electricity by different channels to the ground. The lower end of the conductors should be carried down into the earth, till it reaches either water, or at least a moist stratum.

For the protection of ships, chains, made of a series of iron rods linked together, are most convenient, on account of their flexibility. They should extend from the highest point of the mast some way

into the sea, and the lower part should be removed to some distance from the side of the ship, by a wooden spar or outrigger.

Electrical Condenser. In cases of electrical investigation in which the intensity is very low, the condenser becomes a valuable adjunct to the electrometer. It is shown at *Fig.* 5, *Plate* 2, Electricity, and consists of a disc of brass attached to a delicate electrometer, in the front of which is placed another moveable plate. Volta appears to have been the first electrician who constructed an apparatus of this description. His condenser of electricity consisted of a flat and smooth metal plate, furnished with an insulating handle, and a semi-conducting or imperfectly insulating plane. The principle on which the action of this apparatus depends, is that the metal plate, whilst standing contiguous to the semi-conducting plane, will both absorb and retain a much greater quantity of electricity than it can either absorb or retain when separate, its capacity being increased in the former, and diminished in the latter case.

This condenser has been greatly improved by Mr. Cavallo, who employed a small metallic plate about the size of a shilling, having affixed to it a glass handle covered with sealing-wax. When the latter plate appeared so slightly electrified by the communicated electricity as not to effect the electrometer, he then placed the small plate on the plane, and touched it with the edge of the large one, holding the latter in an almost vertical position; the small plate was thus found to indicate a very sensible degree of electricity.

Electrical Doubler. This instrument bears some analogy to the one we have already described. It is shown in its simplest form at *Fig.* 5, *Plate* 1, Electricity. In the centre is placed a brass ball supported by a glass leg. There are two brass plates or discs, A C, which are stationary, and a moveable one which is made to revolve with a handle. The precise mode of operation can however only be understood by referring to another view of the instrument. A C, *Fig.* 6, represents the same discs as in the former figure, and the moveable plate is shown at B. The insulating handle is indicated at L P. M represents the top of the stand on which the whole apparatus revolves, and G and H two projecting arms. Small wires also project at E F. If we suppose a faint degree of electricity communicated to the disc B, and it is brought opposite A, the stratum of air between operates like a plate of glass, and by induction A becomes negatively charged, and will receive electricity, but on withdrawing B, the plate A will give a powerful spark. This is given between E and G. A similar effect is found to occur between F H, each time the effect being encreased. D forms a species of prime conductor.

Electrometer Gold Leaf. We have already described several instruments for measuring the intensity of electrified bodies, and have fully examined the principle of their construction. But the one contrived by Mr. Singer is so valuable for its simplicity and delicacy of construction as to warrant a particular notice. The instrument is shown at *Figs.* 3 and 4, *Plate* 2, Electricity. The first represents the external form, and the latter, the internal construction. The following brief description will suffice to convey a correct idea of it. It is formed of a glass cylinder surmounted by a broad cap of either wood or metal. The insulation depends on a glass tube of four inches long, and one fourth of an inch in diameter, covered on both sides with sealing-wax, and having a brass wire of a sixteenth of an inch thick and five inches long, passing through its axis, so as to be perfectly free from contact with any part of the tube in the middle of which it is fixed by a plug of silk, which keeps it in a concentric position with the internal diameter of the tube. A brass cap is screwed upon the upper part of this wire; it serves to limit the atmosphere from free contact with the outside of the tube, and at the same time to defend its inside from dust. To the lower part of the wire the gold leaves are fastened. The glass tube passes through the centre of the cap of the electrometer, and is cemented there about the middle of its length. When this construction is considered, it will be evident, that the insulation of the wire, and also of the gold leaves, will be preserved, until the inside as well as the outside of the glass tube becomes coated with moisture; but so effectually does the arrangement preclude this, that some of these electrometers have remained for years, without being either warmed or wiped, and have still appeared to retain the same insulating power as at first.

Electrophorus. This is a very cheap piece of apparatus, and is frequently employed as a substitute for the electrical machine. It is represented at *Fig.* 6, *Plate* 2, Electricity. The construction is exceedingly simple and may be easily understood. Procure two circular plates of metal, or of wood covered with tin-foil, carefully rounded at the edges; these are the conductors; between them is placed a resinous plate, formed by melting together equal parts of shell-lac, resin, and Venice turpentine, and pouring the mixture, whilst in a fluid state, into a hoop formed of tin of the required size, placed on a marble table, from which the plate may be easily separated when cold. This plate should be about half an inch in thickness; it is sometimes made by pouring the mixture on one of the conductors, which is then formed with a rim for that purpose. In the centre of the upper conductor is fixed a glass handle, A, that it may be lifted without drawing off its electricity, and when the electric state of the lower conductor is to be examined, the whole apparatus must be placed on an insulating stand.

To use the electrophorus the upper surface of the resinous plate must be excited with a piece of dry fur, and it will be electrified negatively. Place the upper conductor, *c*, upon it, and then raise the same by its insulating handle; it will be found to exhibit very faint, if any, electrical signs. Replace the conductor, and whilst it lies on the surface of the excited plate, touch it with a finger or any other uninsulated conductor, and then raise it again by its handle. It will now be positively electrified, and afford a spark at B. If it be then placed on the resinous plate, touched and again raised, another spark will be procured, and this process may be repeated for a considerable time without any perceptible diminution of effect.

The facility with which inflammable air is lighted by even a moderate electric spark, suggested to Volta the construction of an inflammable air lamp: it consists of a reservoir filled with hydrogen gas subject to the constant pressure of a column of water, and confined by a stop-cock, which, when opened, permits it to escape in a slender stream from a small aperture. In a box beneath the vessel of gas an electrophorus is placed, and a wire passes through a glass tube from the upper part of this box to the opening of the stop-

cock. The cover of the electrophorus is connected by a silk string with the handle of the stop-cock, so that the same motion that opens the cock raises the cover of the electrophorus, and the spark that passes from it is conveyed by the insulated wire to the stream of gas, which it inflames.

ELECTRO-MAGNETISM; the name applied to a very interesting class of facts, principally developed by Sir Humphry Davy, Professor Faraday, and Professor Oersted, of Copenhagen. The power of lightning in destroying and reversing the polarity of a magnet, and of communicating magnetic influence to iron previously not magnetic, had long been observed, and had led to the supposition that similar effects might be produced by the common electrical or galvanic apparatus. The first observation of Professor Oersted was, that an electrical current, such as is supposed to pass from the positive to the negative pole of a voltaic battery, along a wire which connects them, causes a magnetic needle, placed near it, to deviate from its natural position, and to assume a new one, the direction of which depends upon the mode of conducting the experiment. The metallic wire to be made use of, in this experiment, should be two or three feet in length, in order to allow of its being bent or turned by the hands in various directions, and is called the *conjunctive wire*. When the wire is extended horizontally in the line of the magnetic meridian, with a freely suspended compass needle, whose centre is directly under the wire, the needle instantly deviates from the magnetic meridian, and declines towards the west, under that part of the conjunctive wire which is nearest the negative electric pole, or the copper end of the voltaic apparatus, the amount of declination depending upon the strength of the electricity, and the sensibility of the needle. If we change the direction of the conjunctive wire out of the magnetic meridian towards the east or the west, no change in the above result takes place. except that of its amount. But if the wire be disposed horizontally beneath the needle, the effects take place in an inverse manner; i. e. the pole of the needle, under which is placed the portion of the conjunctive wire, which receives the negative electricity of the battery, declines towards the east.

When the conjunctive wire is stretched alongside of the needle in the same horizontal plane, it occasions no declination, either to the east or west; but it causes it merely to incline in a vertical line, so that the pole adjoining the negative influence of the battery on the wire, dips when the wire is on its west side, and rises when it is on the east. If we stretch the conjunctive wire, either above or beneath the needle, in a plane perpendicular to the magnetic meridian, it remains at rest, unless the wire be very near the pole of the needle; in which case it rises when the entrance takes place by the west part of the wire, and sinks when it takes place by the east part. When we dispose the conjunctive wire in a vertical line opposite the pole of the needle, and make the upper extremity of the wire receive the electricity of the negative end of the battery, the pole of the needle moves towards the east; but if we place the wire opposite a point betwixt the pole and the middle of the needle, it moves to the west. The phenomena are presented in an inverse order, when the upper extremity of the conjunctive wire receives the electricity of the positive side of the apparatus.

The foregoing observations induced professor Oersted to believe that the electric action is not inclosed within the conducting wire, but that it has a pretty extensive sphere of activity around it. He also concluded that this influence acts by revolution; for, without such a supposition, it is impossible to conceive how the same portion of wire, which, placed beneath the magnetic pole, carries the needle towards the east, should, when placed above this pole, carry it towards the west. Such was the nature of the first discovery in electro-magnetism. It was no sooner announced, than the experiments were repeated and varied by philosophers in all parts of the world; and a multitude of new facts were soon brought to light through the labours of Davy, Faraday, Ampère, and Biot.

Two very important facts were ascertained by Ampère and Davy,—that the conjunctive wire becomes itself a magnet and that magnetic properties might be communicated to a steel needle not previously possessing them, by placing it in the electric current. The former of these facts is proved by throwing some iron filings on paper, and bringing them under the wire, when they will immediately adhere to it, forming a tuft round it ten or twelve times the diameter of the wire: on breaking the connection with the battery, however, they immediately fall off, proving that the magnetic effect depends entirely on the passage of the electricity through the wire. The degree of force of this magnetic property thus communicated to the uniting wire was imagined, by Sir H. Davy, to be proportional to the quantity of electricity transmitted through it. Hence the finer the wire, the more powerfully magnetic was it rendered; and hence, also, a battery of very large plates, such as is used for producing intense heat and light, was found to give the strongest magnetism to the wire connecting its poles. Accordingly we find that the calorimoter of Dr. Hare, a galvanic arrangement, in which the plates are nearly two feet square, exhibits the strongest magnetic effects, and this, notwithstanding the powerful heating effects that accompany its action; the heat excited not diminishing or interfering with the magnetism, but apparently increasing it; for a fine platina wire, so intensely ignited as to be near the point of fusion, is observed to attract larger quantities of iron filings than when at a lower temperature.

To communicate magnetic properties to steel needles, which before did not exhibit them, it is necessary merely to place them in contact with, or near to, the conjunctive wire. The position in which they are to be placed, with regard to the wire, is important, as the permanence of their magnetic quality depends upon it. If they are placed parallel with it, they lose their magnetism when the connection with the battery is broken, which shows that their magnetism arose only from their forming part of the electric circuit, like the connecting wire itself. But if they are placed across the wire, they become permanently magnetized and retain their power equally with needles prepared in the ordinary way. The polarity is different, however, according as the needle is placed above or below the wire.

When a needle is placed under the uniting wire, the positive end of the battery being on the right hand of the operator, the end of the needle next to him becomes the north pole, and the other end the south pole. On the contrary, when a needle is held above the wire, the reverse of this takes place; the

end next to the observer becomes the south, and the other the north pole. Even the same opposition is observed when needles are placed in a perpendicular position, on different sides of the wire; in those on one side, all the lower ends are found to be north poles, while, in those on the opposite side of the wire, the upper ends are all north poles, and the lower extremities all south poles.

Direct contact of the steel needles with the conjunctive wire is not necessary, for they become instantly magnetic when brought near it, even though thick plates of glass are interposed. As was remarked with regard to the connecting wire, galvanic batteries, consisting of large plates, are most powerful in communicating the magnetic influence.

When the conjunctive wires of two distinct galvanic arrangements are made to approach each other, we observe magnetic attractions and repulsions.—Two wires of copper, silver, or any other metal, connecting the extremities of two galvanic troughs, being placed parallel to each other, and suspended so as to move freely, immediately attract and repel each other, according as the directions of the currents of electricity flowing through them, are the same or different. When both the negative or both the positive extremities of the troughs are turned to the same quarter, so that the electric current passes along each wire in the same direction, the two wires attract each other; but when the position of one of the troughs is reversed, so that the electric currents in the two wires flow in opposite directions, the wires repel each other.

Upon this experiment is founded the most plausible theory of magnetism, viz., that it arises from the attractions and repulsions of currents of electricity, constantly circulating round every magnet. This is conceived to explain the reason why the magnetic needle places itself at right angles to a wire conducting electricity, namely, that the electric current passing along the wire may coincide with that circulating round the magnet. The magnetic effects produced by galvanic arrangements are obtained also by electricity evolved from the common machine, and still more from this power concentrated in the Leyden jar; the magnetism communicated agreeing in every respect as to the permanence of the polarity, the variations when the needle is placed above or below the wire, &c., with that produced by the voltaic pile.

Magnetism is communicated to needles in a different manner from that of placing them across the conjunctive wire. The wire is formed into a hollow screw, or helix, by rolling it round a solid rod, and the needle to be magnetized, wrapped in a paper, or put into a glass tube, is placed in the centre of it, and the communication with the galvanic battery established. This arrangement (according to the theory of M. Ampère) conveys the electric current by the spiral convolutions, round and round the needle, and communicates to it, or developes in it, the electric circulation constituting magnetism. By this contrivance it is found that a maximum effect is obtained in a shorter time than by any other method. The position of the north and south pole varies according as either end of the helix is connected with the positive or the negative pole, which shows that the electric current flows along the uniting wire from the positive or zinc extremity to the negative or copper end of the pile. The electricity of a common machine produces the same effect.

Having alluded to the principal facts relating to electro-magnetic phenomena, the ingenious theory of M. Ampère, by which they are explained more extensively and with more precision than by any other hitherto advanced, deserves to be stated. It is the more deserving of attention, as having led its author to the discovery of some of the most remarkable facts detailed above; and if future researches shall continue to increase its probability, it will no doubt be regarded as one of the finest instances of correct induction, supported by minute experiment, which the history of any science can exhibit. The first principle of this theory has been already stated;—that two currents of electricity attract when they move parallel to each other and in the same direction, and repel when they move parallel to each other in contrary directions. This fact is directly the reverse of the usually observed phenomena of electricity; for it is well known that bodies in the same state of electricity repel each other, and in opposite states attract. Hence M. Ampère infers, that these results are not produced by electricity in its known and common state of tension, but are dependent on properties belonging to electricity, previously unsuspected, and peculiar to it when in motion, or flowing in currents. Electricity, when accumulated, has the power of causing certain effects, particularly attractions and repulsions, which are familiar to us, and are called *electrical;* but when moving in currents, it exerts new powers, and these constitute magnetism.

Reviewing the various experiments which have been enumerated, we find, that the connecting wires of two batteries attract and repel each other, according to the direction of the electric currents flowing through them; that the magnetic needle is, exactly in the same manner, attracted and repelled by a connecting wire, according to the direction of the current of electricity moving through the wire; that the position of the needle may be varied, in almost any degree, by changing the position of the connecting wire; that whenever the electric circuit is broken, this influence on the needle ceases, and is renewed whenever the communication between the poles of the battery is restored; that the connecting wire, of whatever metal it may consist, becomes a perfect magnet, as long as the current flows along it, so as to attract iron filings and small steel needles, without attracting copper filings, or any other metal but iron; that steel needles may be converted into permanent magnets, by simply placing them across the connecting wire; that the electric currents having this magnetizing power are not, like accumulated electricity, confined by glass, or other non-conductors, but pass through all bodies with facility, as magnetism was before known to do; that the magnetizing power is exerted by electricity, whether procured by a galvanic apparatus, or a common machine; that powerful magnets may be formed, by conducting electric currents round steel wires, as in the helix, and that the position of the north and south poles of these magnets depends upon the direction in which the currents are made to move round them.

These, and a great number of other facts, it is conceived, clearly demonstrate the perfect resemblance, or rather identity, of electricity and magnetism.—Magnetic phenomena are thus, in fact, a series of electrical phenomena; and magnetism may, with propriety, form a branch of electricity, under the head of *Electrical Currents.* Though this intimate

relation or identity be admitted, it is not so obvious how, by it, the properties of the common magnet are explained. Currents of electricity, according to the theory, are essential to the production of magnetic phenomena; but these are not obvious in a common magnet. M. Ampère has suggested their existence, however, and has so arranged them theoretically, as to account for a great proportion of magnetic appearances. A magnet he conceives to be an assemblage of as many electrical currents, moving round it in planes perpendicular to its axis, as there may be imagined lines, which without cutting one another, form closed curves round it. Magnetization, he says, is an operation by which there is given to the particles of steel (which, of the more common metals, appears to be the only one capable of being permanently impressed with this power) an electro-motive energy, which causes a circulation of these currents to be continued round them.

The excitation and continuance of this electro-motive action is rendered less improbable, when we consider the electric power developed in the tourmaline and boracite by heat alone, and when we find, as in the electrical columns of De Luc and Zamboni, that electricity may be generated for years without ceasing or diminishing, by a small and simple apparatus. Such, then, is the constitution of a permanent magnet. It is a mass of iron or steel, round the axis of which electric currents are constantly circulating, and these currents attract all other electric currents flowing in the same direction, and repel all others which are moving in an opposite direction.

From these attractions and repulsions another effect follows, that the currents of one magnet have always a tendency to move any other magnet near it, till the currents in the second shall coincide in direction with those of the first. It is from this cause, as will presently be explained, that the magnetic needle always turns to the meridian, and that the needle in Oersted's experiments settled at right angles to the connecting wire. One important circumstance is always to be kept in view, that the electric currents flow round every magnet in the same direction in reference to its poles. If, for instance, we place a magnet with its north pole pointing to the north, in the usual position of the magnetic needle, the current of electricity flows round it from west to east; or, on the eastern side of the magnet, it is moving downwards, and on the western side upwards; on the upper side, from west to east, and on the lower side, from east to west. This, it is found, is a uniform law.

On these principles the phenomena of magnetism are easily accounted for. Thus, to take one of the most obvious and well known facts, that of two magnets attracting when their opposite poles are approached to one another, as the north of one to the south pole of the other. Let us suppose a magnet in the position which has just been stated, with its north pole directed to the north; and let a second magnet be placed beyond it, and in a line with it, with its north pole also pointed to the north. Then, it is obvious that the south pole of the second magnet will be next to the north pole of the first; and from their position it follows, that the electric currents must be flowing in the same direction, or, in both of them, from west to east: hence, as currents moving in the same direction attract, these opposite poles, if within a certain distance, ought to attract each other, which, accordingly, will be found to be the case. Now, let the second magnet be reversed; let its south pole be directed to the north, and its north pole approached to the north pole of the first magnet; the electric currents will flow round the magnet in the same manner as before; but in reference to the first magnet and to the meridian, their direction will be reversed: their direction will now be from east to west, upwards on the eastern side, and downwards on the western; consequently, the currents in the two magnets being now opposite, will repel, or the two north poles will repel each other.

In the experiments of Professor Oersted, it was found, as has been stated, that when the extraneous influence of the magnetism of the earth was counterbalanced, the tendency of a magnetic needle always was to place itself at right angles to the wire connecting the poles of the galvanic battery. The reason of this is easily explained upon the present hypothesis. In the needle, the currents flow round its axis from end to end; but in the connecting wire there is no circulation round the axis, but a constant stream from one end, namely, the negative, to the other, the positive extremity: hence, for the current along the wire to coincide with the current across and round the magnet, it is necessary that the latter shall stand across the former; and as it appears, that from the attractions and repulsions which these electric currents exert, they are able to move one or both of the magnetic bodies (according as they are light and mobile), till they coincide, the needle moves if the wire is fixed till it stands at right angles to the wire; and if the magnet is fixed, and the wire moveable, the reverse happens. The other phenomena, of the needle turning to the west when placed below the wire, to the east when placed above it, &c., may with facility be explained in the same manner by the principles, that currents flowing in the same direction attract; and that in every magnet they move in a constant current, which is, when the north pole is turned to the north, from west to east, or upwards on the west side, and downwards on the east side.

The developement of permanent magnetism in steel needles when placed across the wire, while it is only temporary when they are fastened parallel with it, depends on the same cause: in the latter case, it arises merely from the transmission of electricity from end to end, while, in the former, the electro-motive energy of the particles is developed and called into action, which, when set in motion, seems to have the power of continuing itself. These electric currents have the power, which accumulated electricity has not, of penetrating all substances, as was before known respecting magnetism. This is probably owing to their low state of tension; and, in conformity with this, large plates, which evolve electricity in but a slight intensity, produce magnetic effects most distinctly. The agency of galvanism, and that of common electricity, are equally capable of giving rise to magnetism when flowing in currents, which adds another to the proof that these are the same power.

To complete the view of Ampère's doctrine, it remains only to explain the influence of the earth on the magnet, by which the needle is kept always in one position, nearly coinciding with the meridian. He asserts, that currents of electricity, analagous to those which circulate round every magnet, are con-

stantly flowing round the globe, as the current of electricity in a galvanic apparatus moves in an unbroken circuit from the negative to the positive pole, and from it, by the connecting wire, round again to the negative pole. The direction of these currents he infers to be the same as has been stated with artificial magnets; and it is simply by thé attractions and repulsions of these terrestrial currents, bringing the currents round the needle to coincide with them, that the latter always points to the north.

To detect these currents, and to exhibit their influence without the aid of any common magnet, M. Ampère contrived a small electric apparatus, which was distinctly affected by the magnetic influence of the globe. It consisted merely of a copper wire bent into a circle, with the two extremities brought near to each other. It was supported so as to move with the greatest facility; and the points were immersed in basons of mercury, with which the wires of a galvanic battery were connected.

When the communication was established so as to cause a current of electricity to pass through the circle, it immediately began to move, and, after some oscillations, placed itself nearly at right angles to the meridian, or east and west, or so that the electric current passed downwards on the eastern side, and upwards on the western side. This, it has been stated, is exactly the direction in which the currents in every magnet move (supposing it placed with its north pole to the north). The circle may, therefore, be regarded as a section across the axis of a magnet, or as representing one of the currents flowing round it; and if a number of these circles were placed one beyond another, the farthest would point, like the end of the needle, to the north pole, and the nearest to the south pole. However the experiment was varied, the circle always placed itself east and west: if the galvanic current was, by reversing the connecting wires, made to flow in an opposite direction, the circle turned round a semicircle, and still stood east and west, and so that the electric current should always flow downwards on the eastern side, and upwards on the western side Here, then, are distinct marks of magnetism, particularly that most characteristic one of the axes pointing always to the north, which can be attributed only to the combined influence of electric currents moving round the earth.

The annals of philosophy contain many highly interesting papers on the subject of electro-magnetism; but the only work published in this country which fully combines the experimental with the theoretical branch of the subject is from the pen of Mr. Watkins, Curator of Philosophical Apparatus to the University of London. From this work we may select a few of the most striking experiments.

We have already alluded to the revolution which may be produced in an electrified wire. *Fig.* 1, *Plate* 1, Electro-Magnetism, represents an apparatus for illustrating this phenomenon. It consists of a glass cylinder, mounted upon an iron wire, affixed to a wooden support, and having a copper wire loop passed through the centre of its top, and a metal cup to contain mercury above the wire loop. The soft iron wire of the support projects above the bottom of the glass cylinder, and is rounded at its top. Mercury is placed within the lower part of the glass cylinder, and also in another cup, formed in the wooden support. A platinum wire, having a loop formed at its upper end, is loosely hung to the loop above, and touches the surface of the mercury within the glass cylinder. Upon making a communication with a voltaic battery, by means of two connecting wires placed in the mercury in the upper and lower cups, and bringing a magnet into contact with the lower part of the iron wire, which projects below the wooden support for that purpose, the effects of the electro-magnetic action will be observed by the revolutions of the platinum wire round the iron wire, which is a magnet, whilst the real magnet is kept in contact with it. The wire generates the surface of a cone, its lower extremity the circumference of its base; hence the point of suspension is the vertex, and the iron wire magnet is in the centre of the base.

Fig. 2, represents an apparatus to show the vibratory motion communicated to an electrified wire, from the effects of a magnet. It consists of a wooden basis, upon which is affixed a bent brass standard, having at its upper end a vertical wire screwed into it, which wire supports a cup to contain mercury, and has at its lower end soldered a piece of platinum wire formed into a loop. To this loop is freely hung a light platinum wire, the lower end of which touches the surface of some mercury, which is contained in a trough formed in the wooden basis. Another cup to contain mercury is also affixed to another wire, which passes through the basis into the mercury in the trough. On making a communication with a voltaic battery by means of two connecting wires, as usual, the current is made to pass along the loose platinum wire, and the circuit is thus completed; but no motion of the platinum wire is here perceptible, until a powerful horseshoe magnet is placed in a horizontal position on the basis, with its poles inclosing the pendent wire, when that wire instantly acquires a vibratory motion. On reversing the situations of the connecting wires, or of the poles of the magnet, the vibrations will be in an opposite direction.

Fig. 3, exhibits an apparatus which, when adapted to a fixed stand, illustrates the directive property of the freely suspended electrified wire. It consists of a slender copper wire, bent into a flat spiral coil, its upper end terminating in a reversed hook finely pointed, and its lower end pendent in a line coinciding with the pointed part of the reversed hook. The wire coil is secured to a circular disc of card, the wire from the central coil passing through the card and descending below it. When the straight wire is removed from the apparatus and the flat spiral coil arranged with the point of the reversed hook inserted in the top cup, and its lower extremity dipping into the mercury contained in the trough, the two ends being previously amalgamated, and the coil having free motion about its vertical axis; upon transmitting electricity from a voltaic battery through the spiral coil of copper wire, it has a tendency to range itself in a plane perpendicular to the magnetic meridian, and is also very obedient to the magnet.

Fig. 4, is a view of an apparatus to show the contrary rotation of two electrified wires, each about its respective axis, by the joint effects of electricity and magnetism. It consists of a horseshoe magnet, firmly screwed to a wooden basis or support, two helical coils of copper wire, having slender bars across their tops, with needle points in their centres,

Fig. 1.

Fig. 2.

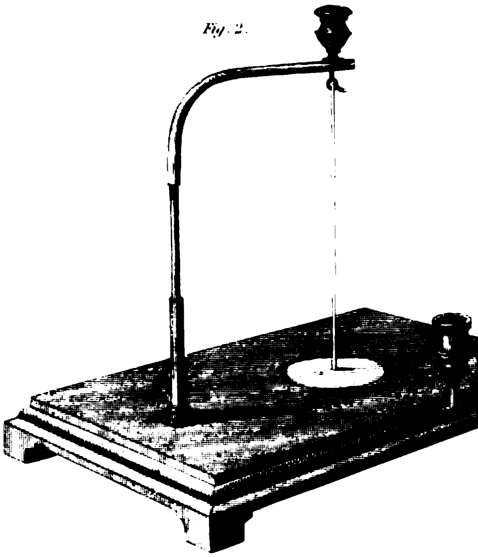


Fig. 3.

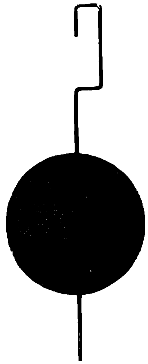
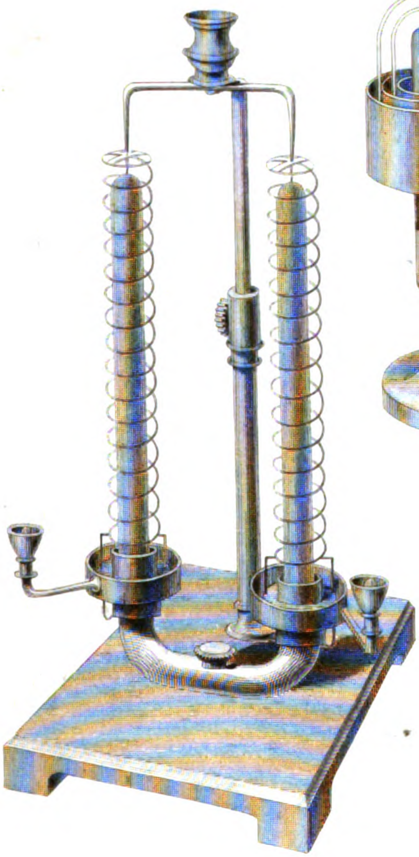


Fig. 4.



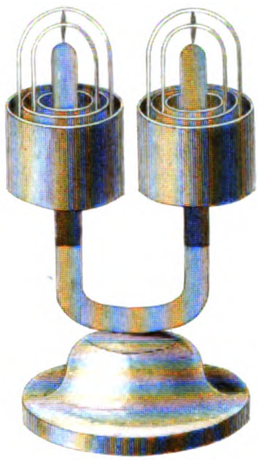


Fig. 5.

Fig. 6.

Drawn by C. Blunt

London. Published by William Orr. Paternoster Row. June 1833

Engraved by W.H.L.

turning in conical holes drilled in the ends of the magnet, and above the points two small platinum cups, to hold a globule of mercury in each. Two wooden cisterns are attached by screws on the lower parts of the magnet, having bent arms fixed in them. To the lower ends of the helical coils are soldered slender pointed wires, bent so as to enter slightly into mercury placed in the two larger cups, mercury being also placed in the small cups. A brass standard affixed to the basis of the apparatus has a forked piece attached to it, with two points descending into the two platinum cups upon the tops of the coils; and there is also another cup placed upon the forked piece to contain mercury. The voltaic circuit is completed by placing wires in the mercury contained in the small side cups, and connected with the copper parts of the batteries; and other wires communicating with the zinc parts are placed in the cup on the top of the apparatus. When the electric stream flows through the apparatus, the helical coils revolve rapidly in contrary directions; but on changing the disposition of the connecting wires, the revolutions of the wires will be reversed. The points of the various wires must be very clean or amalgamated, and the mercury in the cisterns and cups free from dirt.

Fig. 5, represents an apparatus constructed to exhibit the rotation of electrified wires about the poles of a horseshoe magnet, independent of a separate voltaic battery. It consists of a horseshoe magnet, firmly affixed to a metal foot at its bent part; its two ends being made rounding, and having a small hole in the centre of each, at the bottom of which hole an agate cup is placed, and in which, pointed wires affixed to the parts hereafter to be described are made to revolve. A double cylindrical copper vessel, having a bent metal wire affixed to the top of its innermost cylinder, with a vertical wire pointed at both ends, affixed in the middle of that bent wire, is hung upon the upper end of each pole of the magnet, the lower points of the vertical wires of each vessel entering the holes formed, as above described, in the magnet for that purpose. Two hollow cylinders of zinc, each furnished with similar bent wires, having holes made in the underside of each, are then placed within the double copper vessels; the holes in the bent wires being hung upon the uppermost pointed ends of the vertical wires before mentioned. Diluted acid being then poured into the space between the two copper cylinders, the voltaic action commences, and presents the phenomena of the whole of the four cylinders revolving upon their axes; the copper vessels revolving in opposite and contrary directions, and the zinc cylinder turning in opposite directions to them; the rapidity of their revolutions depending upon the strength of the diluted acid, and the delicacy of their suspension. It is evident that a single pair of cylinders may be hung upon one end of a straight or bar magnet placed vertically, and will perform in a similar manner; their rotation being reversed on changing the poles of the magnet. Or a single pair of cylinders may be hung upon either end of a horseshoe magnet if preferred.

Fig. 6, represents an apparatus to exhibit the rotation of two compound rectangular metallic frames about the poles of the magnet, by the mutual influence of a thermo-electric current of magnetism. It consists of a horseshoe magnet supported in a vertical position, upon a brass foot; through a hole made in the curved part of which, a wire passes from the foot, and supports a spirit lamp. In the centre of each upper end of the magnet an agate cup is cemented, in which turns a vertically pointed wire, to the upper end of which two crossing rectangles, or light compound wire frames, are united, composed either of silver and platinum, or platinum and copper; and are united below to wire circles, which surround the arms of the magnet. When the lamp is lighted, the flame heats the lower corners of the rectangles next to it, or rather within it: a thermo-electric current is thereby established in these rectangles, and by its action causes them to rotate in opposite and contrary directions.

There is one more experimental arrangement of the magnetic with the galvanic apparatus, which so fully illustrates the identity of magnetism with galvanism and light as to warrant peculiar attention. This apparatus is now (April, 1833) exhibiting in the National Gallery of Science. The magnet is of the horseshoe form, and is composed of twelve shear steel plates, each twenty-eight inches in length from the poles to the centre edge, three inches wide, and forming together a thickness of four inches. The "keeper" or "bar" is made of the purest soft iron. Around the middle of the "keeper," and occupying with its lower section the space between the poles, is a wooden "winder," having about one hundred yards of common threaded bonnet-wire, from which the two ends, composed of four lengths of the wire twisted together, are carried out, with a vertical curve of about three-fourths of a circle; one of these twisted ends passes beyond each end of the "keeper," and rests upon the respective poles of the magnet. A small wooden lever is so fixed in a frame, to the "winder" and "keeper," as to admit of their being suddenly forced up from the magnet by a sharp stroke; and a very beautiful and brilliant spark is invariably elicited at whichever end of the wire the separation takes place. This spark is capable of igniting gunpowder.

With regard to the cause of the electric currents inferred to be constantly circulating round the globe, it is as yet in obscurity. They are supposed to move at right angles to the magnetic meridian, or nearly parallel with the equator, on the eastern side of the earth moving from us, and on the western side flowing towards us. These currents may be compared to that which flows from the negative pole of a voltaic battery in action, to the positive pole, and, by the medium of the uniting wire, round again to the negative pole. It is conjectured, that the arrangement of the materials of the globe may be such as to constitute a battery, existing like a girdle round the earth, which, though composed of comparatively weak elements, may be sufficiently extensive to produce the effects of terrestrial magnetism. Its irregularity, and the changes which it may accidentally or periodically suffer, may explain the phenomenon of the variation of the compass; or the general action producing the currents of electricity may be affected by different causes, as the earth's motions, currents of the atmosphere, evaporation, or the solar heat. It is supposed that much of the variation depends on the progress of oxidation in the continental regions of the globe. What is called the diurnal variation may be conceived to be produced by the diurnal change of temperature in the superficial layers of the earth, which possess electro-motive energy.

ELECTUARY. Electuaries are medicines chiefly composed of powders of various kinds, mixed up with syrup or honey into such a consistence, that the powders may not separate by keeping. The ingredients of electuaries are chiefly the milder drugs, those which may be taken a good deal *ad libitum*, such as the milder aperients, or aromatics and alteratives, in which a certain latitude may be allowed in the quantity without material risk.

ELEMENT; a term applied in chemistry to a body which has not yet been decomposed. The elements of the ancients were bodies which they supposed to be absolutely simple, and capable of forming all other bodies by their mutual combination; whereas the elements of the moderns are regarded as simple, merely in respect to the present state of the art of analyzing bodies. The progress of chemical science, for several centuries past, has mainly consisted in carrying still farther the analysis of bodies, and in proving those to be compound, which had before been thought elementary.

ELEMI, in *commerce;* a resin obtained from the *Amyris elemifera*, a tree growing in various districts of America, Turkey, &c. It is obtained by wounding the bark in dry weather, the juice being left to thicken in the sun. Its colour is a pale yellow, semitransparent; at first softish, but it hardens by keeping. Its taste is slightly bitter and pungent. Its smell, which is, at first, strong and fragrant, gradually diminishes. It formerly arrived in this country in long roundish cakes, wrapped in flag leaves, but it is now usually imported in mats and chests.

ELEPHANTIASIS; a disease so called from the legs of people affected with it growing scaly, rough, and large, at an advanced period, like the legs of an elephant. The disease attacks the whole body, but mostly affects the feet, which appear somewhat like those of the elephant. It is known by the skin being thick, rough, wrinkled, unctious, and void of hair, and mostly without the sense of feeling. It is said to be contagious. Cullen makes it a genus of disease in the class *cachexiæ*, and order *impetigines*. Elephantiasis has generally been supposed to arise in consequence of some slight attack of fever, on the cessation of which the morbid matter falls on the leg, and occasions a distension and tumefaction of the limb, which is afterwards overspread with uneven lumps, and deep fissures. By some authors it has been considered as a species of leprosy; but it often subsists for many years without being accompanied with any of the symptoms which characterize that disease. It sometimes comes on gradually, without much previous indisposition; but more generally, the person is seized with a coldness and shivering, pains in the head, back and loins, and some degree of nausea. A slight fever then ensues, and a severe pain is felt in one of the inguinal glands, which, after a short time, becomes hard, swelled, and inflamed. No suppuration, however, ensues; but a red streak may be observed running down the thigh from the swelled gland to the leg. As the inflammation increases in all the parts, the fever gradually abates, and, perhaps, after two or three days' continuance, goes off. It, however, returns again at uncertain periods, leaving the leg greatly swelled with varicose, turgid veins, the skin rough and rugged, and a thickened *membrana cellulosa*. Scales appear also on the surface, which do not fall off, but are enlarged by the increasing thickness of the membranes; uneven lumps, with deep fissures, are formed, and the leg and foot become at last of an enormous size.

A person may labour under this disease many years without finding much alteration in his general health, except during the continuance of the attacks; and perhaps the chief inconvenience he will experience is the enormous bulky leg which he drags about with him. The incumbrance has, indeed, induced many who have laboured under this disease to submit to an amputation; but the operation seldom proves a radical cure, as the other leg frequently becomes affected. Hilary observes, that he never saw both legs swelled at the same time. Instances where they have alike acquired a frightful and prodigious size, have, however, frequently fallen under the observation of other physicians.

ELIXIR, is the name of several medicines, consisting of wine or spirits of wine and various resinous, bitter, vegetable substances. The word, however, is almost gone out of use, and its place supplied by *tincture*. Elixirs, indeed, differ from tinctures, by having a thicker and more opaque consistence, and by containing less spirit. The stomach elixirs of Frederic Hoffmann and Stoughton are well known. The former (*elix. viscerale, Fr. Hoffmanni*) is prepared by dissolving in Malaga or Hungary wine the extract of card. ben., cent. min., cort. aurant., cort. Chinæ., myrrh. aq., and adding to the solution a little tinct. caryophyll. aromat. and tinct. croci. Stoughton's elixir consists of absynth., gentian. rubr., rhubarb, cascarilla and cort. aurant., steeped in spirits of wine.

ELL; a measure which is found under different denominations, in most countries, whereby cloths, stuffs, linens, silks, &c., are usually measured. The ell English is 5 quarters, or 45 inches; the ell Flemish, 3 quarters, or 27 inches. In Scotland, an ell contains 37 2-10 inches English.

ELLIPSIS, in *mathematics;* one of the conic sections. Kepler discovered that the planets describe such a curve in revolving about the sun. It presents to the eye, at once, variety and regularity, and is, therefore, preferred by painters to the circle for the outline of their pictures. Two points in the longest diameter have this peculiarity: the sum of two straight lines drawn from them to any point in the circumference is always the same, to whatever point they are drawn. An ellipsis may, therefore, be formed by taking two points upon a plane, attaching to them a ring of thread, and following it round with a pencil, keeping it extended in the form of a triangle. The points where the thread is fixed are called the *foci*.

ELONGATION, in *astronomy;* the angle under which we see a planet from the sun, when reduced to the ecliptic; or it is the angle formed by two lines drawn from the earth to the sun and planet, when reduced as above.

EMANATION; a series of philosophical systems which, like most of the ancient, do not adopt a spontaneous creation of the universe by a Supreme Being. This doctrine came from the East. Traces of it are found in the Indian mythology, and in the old Persian or Bactro-Median doctrine of Zoroaster. It had a powerful influence on the ancient Greek philosophy, as may be seen in Pythagoras.

EMASCULATE; to deprive of virility. This is an operation rarely employed on the human race in our quarter of the globe, though most animals kept for

domestic purposes are made to submit to it. An entire change in the habits and tone of voice is the certain result. Emasculated persons fetch a very high price in the east.

Embalming; to embalm, to fill and surround with aromatic and desiccative substances any bodies, particularly corpses, in order to preserve them from corruption. The ancient Egyptians were the inventors of this art. Other people, for example, the Assyrians, Scythians, and Persians, followed them, but by no means equalled them in it. The art has degenerated very much from the high degree of perfection at which it stood among the ancients; perhaps because the change in religious opinions and customs has made the embalming of the dead less frequent. In modern times, only distinguished individuals are occasionally embalmed; but this process does not prevent corruption.

The intestines are taken out of the body, and the brains out of the head, and the cavities filled up with a mixture of balsamic herbs, myrrh and others of the same kind; the large blood-vessels and other vessels are injected with balsams dissolved in spirits of wine; the body is rubbed hard with spirits of the same kind, &c. (See Mummies.) The ancient Egyptians removed the viscera from the large cavities, and replaced them with aromatic, saline, and bituminous substances, and also enveloped the outside of the body in cloths impregnated with similar materials. These were useful in preventing decomposition, and excluding insects, until perfect dryness took place. In later times, bodies have been preserved a long time by embalming, especially when they have remained at a low and uniform temperature, and have been protected from the air. The body of Edward I. was buried in Westminster Abbey in 1307, and in 1770 was found entire. Canute died in 1036; his body was found very fresh in 1776, in Winchester Cathedral. The bodies of William the Conqueror and of Matilda his wife were found entire at Caen, in the sixteenth century. Similar cases are not unfrequent. In many instances, bodies not embalmed have been preserved from decay merely by the exclusion of the air and the lowness of the temperature. Impregnation of the animal body with corrosive sublimate appears to be the most effectual means of preserving it, except immersion in spirits. The impregnation is performed by the injection of a strong solution, consisting of about four ounces of bichloride of mercury to a pint of alcohol, into the blood-vessels, and, after the viscera are removed, the body is immersed for three months in the same solution, after which it dries easily, and is almost imperishable. *Wet preparations*, or those immersed in alcohol or oil of turpentine, last for an indefinite time. A strong solution of muriate of ammonia is now much employed.

Embargo, in *commerce;* an arrest on ships or merchandise, by public authority; or a prohibition of state, commonly on foreign ships in time of war, to prevent their going out of port, sometimes to prevent their coming in, and sometimes both for a limited time.

Embayed; the situation of a ship when she is enclosed between two capes or promontories. It is particularly applied when the wind, by blowing strongly into any bay or gulf, makes it extremely difficult, and perhaps impracticable, for the vessel thus enclosed to draw off from the shore, so as to weather the capes and gain the offing.

Embossing, or Imbossing, in *architecture* and *sculpture;* the forming or fashioning works in relievo, whether cut with a chisel or otherwise. Embossed glass, made by the action of fluoric acid, is used for a variety of purposes.

Embryo; the first rudiments of the animal in the womb, before the several members are distinctly formed, after which it is called the *fœtus*. The time necessary to produce this is different in different species. The human embryo is visible in three weeks: at the end of four, a pulsation is perceptible, which is known to be the beating of the heart. It is now about the size of an ant or fly, and retains its transparency, which, however, gradually diminishes, and, at the end of two months, disappears: the eyes, nose, mouth, ears, and all the members, are distinguishable: it is as large as a bee. In three months, every thing becomes more distinct, the sex becomes evident, and the fœtus grows until it is ushered into the world as a child.

Emery is chiefly found in shapeless masses, and mixed with other minerals. It contains about 80 parts in 100 of alumine, and a small portion of iron, is usually opaque, and about four times as heavy as water. The best emery is brought from the Levant, and chiefly from Naxos, and other islands of the Grecian archipelago. It is also found in some parts of Spain, and is obtained from a few of the iron mines in Great Britain. In hardness, it is nearly equal to adamantine spar, and this property has rendered it an object of great request in various arts. It is employed by lapidaries in the cutting and polishing of precious stones; by opticians, in smoothing the surface of the finer kinds of glass, preparatory to their being polished; by cutlers and other manufacturers of iron and steel instruments; by masons in polishing of marble; and, in their respective businesses, by locksmiths, glaziers, and numerous other artisans. For all these purposes, it is pulverized in large iron mortars, or in steel mills; and the powder, which is rough and sharp, is carefully washed, and sorted into five or six different degrees of fineness, according to the description of work in which it is to be employed.

Emetic; any medicine which is capable of exciting vomiting, independently of any effect arising from the mere quantity of matter introduced into the stomach, or of any nauseous taste or flavour. The susceptibility of vomiting is very different in different individuals, and is often considerably varied by disease. Emetics are employed in many diseases. When any morbid affection depends upon, or is connected with, over distention of the stomach, or the presence of acrid, indigestible matters, vomiting gives speedy relief. Hence its utility in impaired appetite, acidity in the stomach, in intoxication, and where poisons have been swallowed. In the different varieties of febrile affections, much advantage is derived from exciting vomiting, especially in the very commencement of the disease.

In high inflammatory fever it is considered as dangerous, and in the advanced stage of typhus it is prejudicial. Emetics, given in such doses as only to excite nausea, have been found useful in restraining hæmorrhage. Different species of dropsy have been cured by vomiting, from its having excited absorption. To the same effect, perhaps, is owing the dispersion of various swellings, which has occasionally resulted from this operation. The operation of vomiting is dangerous or hurtful in the following cases: where

there is a determination of the blood to the head, especially in plethoric habits; in visceral inflammation; in the advanced state of pregnancy; in hernia and prolapsus uteri; and wherever there exists extreme general debility. The frequent use of emetics weakens the tone of the stomach. An emetic should always be administered in the fluid form. Its operation may be promoted by drinking any tepid diluent or bitter infusion.

Emetin. This principle was discovered by Majendie and Pelletier, as existing in the root of ipecacuanha, and being apparently the matter in which its emetic power resides. This principle they procured by digesting the ipecacuanha in sulphuric ether, which removes the oily and odorous matter, and afterwards digesting the ipecacuanha in alcohol. This tincture is then evaporated to dryness, a portion of solid matter is obtained, and water is digested on this; it affords by evaporation emetin nearly pure. It may be farther purified by adding acetate of lead, which throws down the emetin combined with oxide of lead. By passing sulphuretted hydrogen through this solution, the oxide of lead is precipitated, and the emetin remains in solution.

Emetin is inodorous, with a bitter and somewhat acrid taste. At the heat of boiling water it remains unchanged; at a higher temperature it swells and decomposes without melting. It appears to be a ternary compound of carbon, hydrogen, and oxygen; it is scarcely affected by exposure to the air, except a slight deliquescence in humid air. It is very soluble in water and alcohol, but not in sulphuric ether. Sulphuric acid decomposes and clears it. Nitric acid dissolves it, forming a red-coloured solution, which, after a disengagement of nitric oxide gas, yields crystals of oxalic acid. Muriatic, acetic, and phosphoric acids dissolve it; from these solutions an alkali precipitates it unchanged. The vegetable and animal principles exert scarcely any action on it.

Emetin is powerfully emetic, one grain being sufficient to occasion a violent vomiting. Its chemical properties are not very distinctive.

Empiric, in *medical history*; an appellation assumed by a sect of physicians, who contended, that all hypothetical reasoning respecting the operations of the animal economy was useless, and that observation and experience alone were the foundation of the art of medicine. *Empiric*, in modern medicine, is applied to a person who sells or administers a particular drug, or compound, as a remedy for a given disorder, without any consideration of its different stages, or degrees of violence, in different constitutions, climates or seasons.

Emulsions; a term applied to the imperfect solutions of the fixed vegetable oils in water. They are obtained by rubbing the seeds affording these oils with water to which a little sugar has been added.

Enamelling; the art of variegating with colours laid upon or into another body; also, a mode of painting, with vitified colours, on gold, silver, copper, &c., and of melting these at the fire, or of making curious works in them at a lamp. This art is of so great antiquity, as to render it difficult or impossible to trace it to its origin. It was evidently practised by the Egyptians, from the remains that have been observed on the ornamented envelopes of mummies. From Egypt it passed into Greece, and afterwards into Rome and its provinces, whence it was probably introduced into Great Britain, as various Roman antiquities have been dug up in different parts of the island, particularly in the Barrows, in which enamels have formed portions of the ornaments. The gold cup given by King John to the coporation of Lynn, in Norfolk, proves that the art was known among the Normans, as the sides of the cup are embellished with various figures, whose garments are partly composed of coloured enamels. Enamels are vitrifiable substances, and are usually arranged into three classes; namely, the transparent, the semitransparent, and opaque. The basis of all kinds of enamel is a perfectly transparent and fusible glass, which is rendered either semitransparent or opaque, by the admixture of metallic oxides. The art of colouring glass seems to be of nearly the same antiquity as the invention of making it; which is proved, not only from written documents, but likewise by the variously coloured glass corals, with which several of the Egyptian mummies are decorated.

White enamels are composed by melting the oxide of tin with glass, and adding a small quantity of manganese, to increase the brilliancy of the colour. The addition of the oxide of lead, or antimony, produces a yellow enamel; but a more beautiful yellow may be obtained from the oxide of silver. Reds are formed by an intermixture of the oxides of gold and iron, that composed of the former being the most beautiful and permanent. Greens, violets, and blues are formed from the oxides of copper, cobalt, and iron; and these, when intermixed in different proportions, afford a great variety of intermediate colours. Sometimes the oxides are mixed before they are united to the vitreous basis. All the colours may be produced by the metallic oxides.

The principal quality of good enamel, and that which renders it fit for being applied on baked earthenware, or on metals, is the facility with which it acquires lustre by a moderate heat, or cherry-red heat, more or less, according to the nature of the enamel, without entering into complete fusion. Enamels applied to earthenware and metals possess this quality. Enamels are executed upon the surface of copper and other metals, by a method similar to painting. Enameling on plates of metal, and painting with vitrified colours on glass, are practised with great success in England.

One of the most curious and useful branches of this art consists in the manufacture of watch dials. The accompanying account gives the process employed at the present time in the best manufactories in Paris.

"The dial plates of clocks and watches are made in a variety of ways. In general they are composed of enamell upon a single plate of copper, unless they are more than a foot in diameter: larger ones are made in separate pieces, which are afterwards joined together; or they are made of glass, placed upon a white ground. Some dial plates are made of silver, gold, and silvered or gilt brass.

"The enamelled dial plates are formed of a thin plate of copper, enamelled upon both sides, and having hours and minutes painted upon the ground. To make one of these dial plates, a thin plate of copper, of the requisite size, is taken, and hammered upon a slightly concave anvil of hard wood, with a convex-headed hammer, which speedily reduces it to the proper convexity: a hole is then made in the middle, which is enlarged with a tool put into it from the

concave side, in order to form a ridge round the hole on the convex side, to retain the enamel when in a melted state. The copper plate is then placed upon the platine of the works, fitted to it by passing a tool through the centre holes of each, and being kept in its place by a vice, the holes for the screws by which the dial-plate is to be fastened to the rest of the works, and that by which the key is to be introduced, are made; which last is to have a ridge round it, for the same purpose as that round the central hole. Copper wires are then forced into the holes by which it is to be attached to the works, and cut to the proper length, after which they are soldered. The plate is cut of such a size, that the edge may be hammered up to form a similar ridge round the whole face.

"The copper plate being thus manufactured, it is cleansed, by being left a short time in water sharpened with a little aqua-fortis, until the surface is perfectly clean; it is then dipped in common water, and brushed with a brush of brass wires.

"The enamel used ought to be very white: it is imported and sold by the ironmongers in flat cakes. The cakes are broken in a hardened steel mortar, and reduced, for the most part, into small pieces, about the size of small grains of sand, as nearly equal as possible. These are first washed in very clear water, and the milky liquor poured off, and left to settle, by which the finer powder is separated. The grains of enamel are then washed again several times with a clear water, and the settlings of the water that is poured off, kept as before, for enamelling the under surfaces of the plate.

"The grains of enamel being thus well washed, they are put into a glass vessel, and aqua-fortis is poured on them, so as to float them about a quarter of an inch. The whole is stirred with a glass or spatula, and the acid left on the enamel for twelve hours, in order to dissolve away the metallic particles it has rubbed off the steel mortar, and which would foul the whiteness of the enamel when applied on the face of the plate. The nitric acid is then poured off; and the enamel washed again with water, until all the acid is got rid of; after which it is again covered with clean water, and kept under it to preserve its cleanness and whiteness.

"Not only the convex face of the dial-plate, or that on which the hours and minutes are to be painted, is enamelled, but also the concave face. This counter-enamelling, as it is called, is necessary, lest, when the enamel of the upper face is melted, the action of it on a plate, while hot, should change its curvature; upon which account both faces are enamelled at one and the same time.

"The enamel is first put on the concave or under face, which is done, as has been just said, with the fine settlings obtained in washing the granular enamel. For this purpose, a tool is put into the centre hole, and the water being poured off the settlings, it is taken up with a steel spatula, and spread as equally and as thin as possible over the concave surface; the tool is then taken out, and there is put in its place a bit of clean linen, which draws and absorbs the water; if this precaution were not taken, the counter-enamalling would fall off when the dial-plate was turned over.

"To enamel the convex face the plate is turned over, a tool put in the centre hole, and there is spread over the whole surface a layer of the bruised enamel, as evenly as possible, taking care to cover well the edges of the dial-plate, and those of the various holes, to prevent the heat from burning them. To draw off the water which adheres to the enamel, a piece of fine linen is put round the edge of the plate, which draws out nearly all the moisture; and, in order that the particles of the enamel may arrange themselves properly, and be packed as close as possible, a few slight strokes are given to the tool in the centre hole. The neatness with which this is executed is essential; for to this is owing the beauty, polish, and glassy surface of the dial-plate, by reason that the enamel becoming well packed, there are, when it melts, no hollows below the surface, and hence the surface remains perfectly smooth. In order to be sure that no water remains in the enamel, the dial-plates are dried upon a square sheet of iron turned up on the edges on three sides, and placed over a chafing-dish, where it has its temperature raised.

"The preparation of the dial-plate being finished, it is introduced by degrees under a muffle placed in a furnace, in order that it may be heated gradually. The furnace used in London for this purpose has some peculiarities in its construction: but any muffle furnace, if it be well made, will suffice for the purpose. It is left in this state, until the enamel is perceived to begin to melt, when the sheet of iron, on which the plate is placed, is turned round very gently, in order that the heat may effect every part of the dial-plate equally. When the polish of the surface shows that the enamel is melted, the plate is slowly withdrawn from the furnace, and left for some time at the mouth of the muffle, in order that the enamel may cool very slowly, as otherwise it would crack and split off the plate of copper.

"After the first firing, the plate is again cleaned, as before, with water sharpened with aqua-fortis; and the under surface is examined, and if necessary, retouched with the settlings, as before. A fine layer of enamel is also spread over the convex face, and the plate is again exposed to the fire, with the same precautions as before: a third layer of the finest and whitest enamel is again spread on the upper or convex surface, and fired in the same manner; by which means the dial-plate receives all the beauty of which it is capable.

"The hours and minutes are then enamelled on a convex face with a black, soft enamel, made for this purpose. It is ground very fine, in an agate mortar, with a pestle of the same substance, along with oil of spike, and spirit of turpentine. It is considered necessary that the enamel should be reduced to an impalpable powder, and therefore a half day is usually employed in grinding a single Troy drachm. More oil of spike is then added, to render it sufficiently thin to flow from the pencil.

"The place where the hour of twelve is to be placed having been marked from the first by a slight touch of the file, the dial-plate is then placed on a flat surface, and, by means of a pair of compasses, with one point blunt, and placed truly on the centre, and with the other bearing a black-lead pencil, the lines between which the hours and minutes are to be placed, are slightly traced on the surface. In order to divide these circles, a protractor with a moveable limb is used, and the place of the hours and minutes traced with black lead: these are then painted, and when thoroughly dry, the dial-plate is again fired in the same manner as before, and is then finished.

"The dial-plates of clocks, when they do not exceed twelve or fifteen inches in diameter are enamelled in the same way; but larger dial-plates are made in separate pieces, generally as many as there are hours on the face, and then joined together."—*Partington's Scientific Gazette.*

ENCAUSTIC PAINTING. Painting in encaustic is executed with the operation of fire. Ancient authors often mention this species of painting, which, if it had been described simply by the word *encaustic*, which signifies *executed by fire*, might be supposed to have been a species of enamel painting. But the expressions *encausto pingere, pictura encaustica, ceris pingere, picturam inurere*, by Pliny and other ancient writers. show that another species of painting is meant. We have but few ancient pictures of this description, and, therefore, the precise manner adopted by the ancients is not completely developed, though many moderns have closely investigated the subject, and described their processes. This species of painting appears to have been practised in the 4th and 5th centuries.

Count Caylus, and M. Bachelier, a painter, were the first of modern times who made experiments in this branch of art, about the year 1749. Pliny, in a passage relating to encaustic painting, distinguishes three species: 1. that in which the artists used a style, and painted on ivory or polished wood (*cestro in ebore*), for which purpose they drew the outlines on a piece of the aforesaid wood or ivory, previously soaked or imbued with some colour; the point of the style or stigma served for this operation, and the broad end to scrape off the small filaments that arose from the outlines: and they continued forming outlines with the point till they were finished. 2. The next manner appears to have been one in which the wax, previously impregnated with colour, was spread over the surface of the picture with the style, and the colours thus prepared were formed into small cylinders for use. By the side of the painter was a brasier for keeping the styles continually hot, with the points of which they laid on the colours when the outlines were finished, and spread them smooth with the broad end; and thus they proceeded till the picture was finished. 3. The third manner of painting was with a pencil, in wax liquefied by fire.

By this method the colours acquired a considerable hardness, and could not be damaged, either by the heat of the sun or the effects of sea water. In this manner ships were painted, with emblems and other pictures, and therefore obtained the name of *ship painting*. Few, of late years, have made more experiments in this mode of painting that an English lady, Mrs. Hooker, who, for her very successful exertions in this branch of the polite arts, was presented with a gold palette by the Society for the Encouragement of Arts, &c. Her account is printed in the 10th volume of the Society's Transactions, for 1792, when she was Miss Emma Jane Greenland. This subject has also been deeply investigated by the Chevalier Lorgna, in a small but valuable tract, called *Un Discorso sulla Cera Punica.*

As the thing chiefly regarded in encaustic painting was the securing of permanence and durability, by the application of fire, the word *encaustic* has been applied, in a very general sense, to other processes, in which both the material and the mode of applying the heat are entirely different from the ancient materials and modes. The word has been used, not only of wax-painting on wood, stone and ivory, but also for painting on earthen vessels, of works in metal, where gold and silver were inlaid, melted, or laid on, and of every thing which was gilt or silvered by fire; which was called *gold* or *silver encaustic.* The moderns have also used the term for painting on porcelain, and work in enamel; and in the same way it was given to the painting on glass of the middle ages, such as is now seen in the windows of some Gothic churches. It is evident, that all these have nothing to do with the wax-painting of the ancients.

Professor Reinagle has a painting of Cleopatra executed in encaustic, which is valued at two thousand pounds.

ENDEMIC. This name is often applied to diseases which attack the inhabitants of a particular district or country, and have their origin in some local cause, as the physical character of the place where they prevail, or in the employments, habits, and mode of living of the people. Every part of the world, every climate, and every country, has its peculiar endemics. Thus the tropical and warm climates are subject to peculiar cutaneous disorders, and eruptions of various kinds, because the constant heat keeps up a strong action of the skin, and draws the humours to the surface of the body. In northern climates, eruptions of the skin occur, but they are of a different kind. Thus in all the north polar countries, especially in Norway, a kind of leprosy, the *radesyge*, is prevalent, arising from the coldness and humidity of the climate, which dispose the skin to such disorders.

Hot and moist countries generate the most violent typhus and putrid fevers; the West Indies and some of the American seaports, for instance, produce the yellow fever. Places in a more dry and elevated situation, northern countries particularly, are peculiarly subject to inflammatory disorders. In countries and districts very much exposed to currents of wind, especially in mountainous places, we find at all seasons of the year, rheumatisms, catarrhs, and the whole train of complaints which have their origin in a sudden stoppage of the functions of the skin. In large and populous towns, we meet with the most numerous instances of pulmonary consumption. In places that are damp, and at the same time not warm, as in marshes and larger rivers, intermittent fevers are prevalent. In cold and damp countries, like England, Sweden, and Holland, the most frequent cases of croup occur. Diseases which are endemic in one country, may also appear in others, and become epidemical, if the weather and other physical influences resemble those which are the causes of the endemic in the former place; the climate being for a time transferred, as it were, from one to the other. Thus, for instance, we find the croup sometimes, during wet and cold weather, appearing in high situations; intermittent fevers sometimes in places where they occur rarely for years, and then again attack great numbers; putrid and malignant typhus fevers rage in all countries occasionally; and so of the rest.

Endemic disorders, in some circumstances, become contagious, and thereby spread to other persons, and may be transplanted to other places, the situation and circumstances of which predispose them to receive these disorders. This is known by the sad experience of the migrations of diseases, the spreading of the leprosy from the Oriental countries to Europe, &c.

It is useful to inquire into the endemical circumstances of countries, districts, and even cities and towns; some precautions may be thereby suggested to escape the sickness, or to obviate the unwholesomeness of the situation of the place in question. As, for instance, the physician of Pope Clement XI. Lancini, procured the draining and drying of the marshes about Pesaro; and the diseases which had arisen from the exhalations of these marshes immediately ceased. It is also very favourable to the cure of obstinate disorders, for the invalid to remove to a climate opposed to his particular complaint.

Enfilade, in the *military* art, is used in speaking of trenches or positions, which may be scoured by the enemy's shot along their whole length. In conducting the approaches at a siege, care must be taken that the trenches be not enfiladed from any work of the place. In the celebrated battle of Zorndorf, a shot from a Prussian battery, enfilading a Russian square, killed or disabled 30 men.

Engine; a combination of machinery fitted to perform various mechanical offices. Engineering has now become a very important civil profession; and amongst military men they hold the highest station in the army. The commercial importance of the steam engine warrants our giving it a distinguishing feature under that head, when we purpose furnishing a complete account of the various modes of employing elastic vapour in the construction of steam engines. Water engines will be examined under Hydrostatics and Hydraulics.

Engraving is the art of representing, by means of lines and points produced on a metallic surface by cutting or corrosion, the figures, lights, and shades of objects, in order to multiply them by means of printing. The engraver is to the painter what the translator is to the author. As it is impossible to give a spirited translation of a work of genius without a portion of the author's fire, so it is essential to a good engraver that he should feel and understand the character of his original, and be initiated into the secrets of drawing, that his copy may be at once correct and spirited.

The art of engraving on copper was invented in Europe in the first half of the 15th century. The Chinese seem to have been acquainted with it long before. The Dutch, the Italians, and the Germans compete for the honour of its invention in Europe.—It is known that the art was exercised by the Italian Finiguerra as early as 1460. The inventors of it were the goldsmiths, who were in the habit of making devices on their wares; and these, being often executed with much elegance, excited the desire to multiply copies by transferring them to paper. Engraving differs from printing in having its subjects cut into a hard surface, instead of being raised above it, as is the case with types and wood cuts. Many metals and alloys have been employed for the purpose of engraving. The most common is copper, which is soft enough to be cut when cold, and hard enough to resist the action of the press.

We shall now proceed to explain the methods of executing different descriptions of engraving. The graver, an instrument of steel, is principally used in engraving on copper; it is square for cutting of broad lines, and lozenge for the finest, and must be tempered to that exact state, which will prevent the point from breaking or wearing by its action on the metal. The graver is inserted in a handle of hard wood, resembling a pear with a longtitudinal slice cut off, which is to enable the artist to use it as flat on the plate as his fingers and thumb will permit. This instrument is used for removing the imperfections discoverable in etchings, and exclusively in engraving writing. In working, this instrument is held in the palm of the hand, and pushed forward so as to cut out a portion of the copper. The *scraper* is a long, triangular piece of steel, tapering gradually from the handle to the point; the three edges produced by this form, being sharpened on the oil-stone, are used for scraping off the roughness occasioned by the graver, and erasing erroneous lines. The *burnisher* is a third instrument of steel, hard, round, and highly polished, for rubbing out punctures or scratches in the copper. The oil-stone has been already mentioned. To these may be added the needle, or dry point, for etching, and making those extremely fine lines, which cannot be made with the graver. It is held in the fingers in the same way as a pen or pencil. Various kinds of varnish, resin, wax, charcoal, and mineral acids are also employed in different parts of the operation, according to the subject, and the style of engraving which is adopted. The first which we shall describe is

Line Engraving. To trace the design intended for engraving accurately on the plate, it is usual to heat the latter sufficiently to melt white wax, with which it must be covered equally and thin, and suffered to cool; the drawing is then copied in outlines, with a black-lead pencil, on paper, which is laid with the pencilled side upon the wax, and the back rubbed gently with the burnisher, which will transfer the lead to the wax. The design must next be traced, with an etching needle, through the wax on the copper, when, on wiping it clean, it will exhibit all the outlines ready for the graver. The table intended for engraving on should be perfectly steady. Great care is necessary to carry the hand with such steadiness and skill, as to prevent the end of the line from being stronger and deeper than the commencement; and sufficient space must be left between the lines to enable the artist to make those stronger, gradually, which require it.

The roughness or burr occasioned by the graver must be removed by the scraper, the lines filled by the oil-rubber, and the surface of the copper cleansed, in order that the progress of the work may be ascertained. If any accident should occur, by the slipping of the graver beyond the boundary required, or lines are found to be placed erroneously, they are to be effaced by the burnisher, which leaving deep indentings, these must be levelled by the scraper, rubbed with charcoal and water, and finally polished lightly with the burnisher. As the uninterrupted light of the day causes a glare upon the surface of the copper, hurtful and dazzling to the eyes, it is customary to engrave beneath the shade of silk paper, stretched on a square frame, which is placed reclining, towards the room, near the sill of a window. Such are the directions and means to be employed in engraving historical subjects: indeed, the graver is equally necessary for the remedying of imperfections in etching; to which must be added the use of the dry point in both, for making the faintest shades in the sky, architecture, drapery, water, &c., &c.

Stippling. The second mode of engraving is that called *stippling*, or engraving in dots. This resembles the last-mentioned method in its processes, except that, instead of lines, it is finished by minute points or excavations in the copper. These punc-

tures, when made with the dry point, are circular: when made with the graver, they are rhomboidal or triangular. The variations and progressive magnitude of these dots give the whole effect to stippled engraving. This style of work is always more slow, laborious, and, of course, more expensive, than engraving in lines. It has, however, some advantages in the softness and delicacy of its lights and shades, and approaches nearer to the effect of painting than the preceding method. A more expeditious way of multiplying the dots has been contrived in the instrument called a *roulette*, a toothed wheel, fixed to a handle which, by being rolled forcibly along the copper, produces a row of indentations. This method, however, is less manageable than the other, and generally produces a stiff effect.

Engraving of Mezzotintos differs entirely from the manner above described. This method of producing prints which resemble drawings in India ink, is said by Evelyn, in his history of chalcography, to have been discovered by Prince Rupert. Some accounts say that he learned the art from an officer named Siegen, or Sichem, in the service of Hesse-Cassel. It was, some years past, a very favourite way of engraving portraits and historical subjects; of the former, the large heads of Fry are of superior excellence. The tools required for this easy and rapid mode of proceeding are, the grounding-tool, the scraper, and the burnisher.

The copper-plate should be prepared as if intended for the graver, and laid flat upon a table, with a piece of flannel spread under it, to prevent the plate from slipping; the grounding-tool is then held perpendicularly on it, and rocked with moderate pressure backwards and forwards, till the teeth of the tool have equally and regularly marked the copper from side to side; the operation is afterwards repeated from end to end, and from each corner to the opposite; but it is necessary to observe, that the tool must never be permitted to cut twice in the same place; by this means the surface is converted into a rough chaos of intersections, which, if covered with ink and printed, would present a perfectly black impression upon the paper. This is the most tedious part of the process. The rest, to a skilful artist, is much easier than line engraving or stippling. It consists in pressing down or rubbing out the roughness of the plate, by means of the burnisher and scraper, to the extent of the intended figure, obliterating the ground for lights, and leaving it for shades. Where a strong light is required, the whole ground is erased. For a medium light, it is moderately burnished, or partially erased. For the deepest shades, the ground is left entire.

Care is taken to preserve the insensible gradations of light and shade, upon which the effect and harmony of the piece essentially depend. Engraving in mezzotinto approaches more nearly to the effect of oil-paintings than any other species. It is well calculated for the representation of obscure pieces, such as night scenes, &c. The principal objection to the method is, that the plates wear out speedily under the press, and, of course, yield a comparatively small number of impressions.

Etching. Of engravings which require the aid of aqua-fortis, the principal is etching. He that would excel in this branch of the arts must be thoroughly acquainted with drawing. The ground used in etching is a combination of asphaltum, gum mastic, and virgin wax. The proportions of the ingredients should be obtained by experiment. The copper-plate is hammered to a considerable degree of hardness, polished as if intended for the graver, and heated over a charcoal fire; the ground is then rubbed over it, till every part is thinly and equally varnished. The varnish is then blackened by the smoke of a lamp, that the operator may see the progress and state of his work. The next object is to transfer the design to the ground, which may be done by drawing it on thin white paper with a black-lead pencil, and having it passed through the copper-plate printer's rolling press; the lead will be conveyed firmly to the ground, which will appear in perfect outlines on removing the paper.

Another method is, to draw the design reversed from the original: rub the back with powdered white chalk, and, laying it on the ground, trace the lines through with a blunt point; this operation requires much precaution, or the point will cut the ground. After the plate is prepared, the operator, supporting his hand on a ruler, begins his drawing, taking care always to reach the copper. Every line must be kept distinct, throughout the plate, and the most distant should be closer and more regular than those in the foreground, and the greater the depth of shade, the broader and deeper must the lines be made. When the etching of the plate is completely finished, the edges of it must be surrounded by a high border of wax, so well secured that water will not penetrate between the plate and it. The best aqua-fortis must then be diluted with water, and poured upon the plate, which undergoes a chemical action wherever it has been laid bare by the needle, while the remainder of the surface is defended by the varnish. The bubbles of fixed air, and the saturated portions of metal, are carefully brushed away with a feather. After the operator thinks the acid has acted long enough, he pours it off, and examines the plate. If the light shades are found to be sufficiently bit in, they are covered with varnish, or *stopped out*. The biting is then continued for the second shades, which are next stopped out: and so on. After the process is completed, the varnish is melted and wiped off, the plate cleaned with oil of turpentine, and any deficiencies in the lines remedied with the graver. As the acid cannot be made to act with perfect regularity, etchings will always be rough in comparison with line engravings. This very circumstance, however, fits etching for the representation of coarse objects in nature, such as trunks of trees, broken ground, &c., especially on a large scale. In landscape engraving, we generally find a mixture of methods, the coarser parts being etched, the more delicate cut with a graver. Letters and written characters are mostly cut, and seldom etched.

Steel Engraving was introduced by Mr. Perkins. The steel plate is softened by being deprived of a part of its carbon; the engraving is then made, and the plate hardened again by the restoration of the carbon. The great advantage of steel plates consists in their hardness, by which they are made to yield an indefinite number of impressions; whereas a copper plate wears out after 2000 or 3000 impressions, and even much sooner if the engraving be fine. An engraving on a steel plate may be transferred, in relief, to a softened steel cylinder by pressure; this cylinder, after being hardened, may again tranfer the design, by being rolled upon a fresh steel plate; thus

the design may be multiplied at pleasure. Steel plates may also be etched.

Engraving on precious Stones is accomplished with the diamond or emery. The diamond possesses the peculiar property of resisting every body in nature, and, though the hardest of all stones, it may be cut by a part of itself, and polished by its own particles. In order to render this splendid substance fit to perform the operations of the tool, two rough diamonds are cemented to the ends of the same number of sticks, and rubbed together till the form is obtained for which they are intended; the powder thus produced is preserved, and used for polishing them in a kind of mill furnished with a wheel of iron; the diamond is then secured in a brazen dish, and the dust, mixed with olive-oil, applied; the wheel is set in motion, and the friction occasions the polished surface so necessary to give the lustre due effect. Other stones, as rubies, topazes, and sapphires, are cut into various angles on a wheel of copper; and the material for polishing those is tripoli diluted with water.

A leaden wheel, covered with emery mixed with water, is preferred for the cutting of emeralds, amethysts, hyacinths, agates, granites, &c., &c.; and they are polished on a pewter wheel with tripoli; opal, lapis lazuli, &c., are polished on a wheel made of wood. Contrary to the method used by persons who turn metals, in which the substance to be wrought is fixed in the lathe, turned by it, and the tool held to the substance, the engraver of the crystal, lapis lazuli, &c., fixes his tools in the lathe, and holds the precious stone to them, thus forming vases, or any other shape, by interposing diamond dust mixed with oil, or emery and water, between the tool and the substance, as often as it is dispersed by the rotary motion of the former.

The engraving of armorial bearings, single figures, devices, &c., on any of the above stones, after they are polished, is performed through the means of a small iron wheel, the ends of the axis of which are received within two pieces of iron, in a perpendicular position, that may be closed, or otherwise, as the operation requires; the tools are fixed to one end of the axis, and screwed firm; the stone to be engraved is then held to the tool, the wheel set in motion by the foot, and the figure gradually formed. The material of which the tools are made is generally iron, and sometimes brass: some are flat, like chisels, gouges, ferules, and others have circular heads. After the work is finished, the polishing is done with hair brushes fixed on wheels and tripoli.

Engraving in Wood has been practised for several centuries, and originally with tolerable success; it languished for a great part of the 18th century, but revived towards the close, and is still practised in a manner which reflects credit on the ingenuity of the age. The lines, instead of being cut into the substance, are raised, like the letters of printing types, and printed in the same manner. The wood used for this purpose is box, which is preferred for the hardness and closeness of its texture. The surface must be planed smooth, and the design drawn on it with a black-lead pencil; the graver is then used, the finer excavations from which are intended for white interstices between the black lines produced by leaving the box untouched, and the greatest lights are made by cutting away the wood entirely, of the intended form, length, and breadth; but the deepest shades require no engraving. Much of the beauty of this kind of engraving depends upon the printing. Wood engraving has now attained a very high degree of excellence in this country, so much so, indeed, that the Germans, who were themselves the earliest wood engravers send to this country for cuts. Mr. Bonner is at the head of this walk of art. Wood engravings have this advantage, that they may be inserted in a page of common types, and printed without separate expense. They are very durable, and may be multiplied by the process of stereotyping.

Coloured Engravings. Coloured engravings are variously executed. The most common are printed in black outline, and afterwards painted separately in water-colours. Sometimes a surface is produced by aquatinta, or stippling, and different colours applied in printing to different parts, care being taken to wipe off the colours in opposite directions, that they may not interfere with each other. But the most perfect as well as most elaborate productions, are those which are first printed in colours, and afterwards finished by hand.

Engravers, modern. Among modern nations, the Italians, French, Germans, and English have rivalled each other in producing great works in the department of engraving; but, on the whole, the superiority seems to belong to the Italians and French, at least for the number of their productions; but more particularly for the excellence of their impressions. Many great works, executed in Germany, are sent to Paris to be struck off. In Germany, Frederic von Müller, whose Madonna di S. Sisto is still a jewel in collections, died too early for the art. C. Rahl distinguished himself by his engraving of Fra Bartolomeo's Presentation of Christ in the Temple, and of Raphael's St. Margaret. K. Hess, Reindel, Umer (lately deceased), Leybold, Lutz, and A. Kessler, have produced fine cabinet-pieces. John in Vienna, Kobell in Munich, Barth, Amsler, and Rushweyh in Rome, are distinguished in different branches. Chodowiecki, Bause, Bolt, Clemens, Gmelin, and many others, have contributed much to advance the art of engraving. In general, it may be mentioned as a favourable sign of the times, that all the first artists in Germany apply their talents to great works, whilst the taste for souvenir engravings seems rapidly dying away. Those engravers who have produced the best plates for scientific works, so very important a branch of the art, and those in the department of geography, would deserve to be mentioned, if we had room. France has maintained her early fame, in the art of engraving, down to the most recent times. The engravings of A. Boucher-Desnoyers (for instance, the Madonna di Foligno, La Vierge, dite La Belle Jardinière, Francis I. and Margaret of Navarre, Phædre and Hippolyte, the portrait of the Prince de Benevento) are acknowledged masterpieces. Lignon's St. Cæcilia from Domenichino, his Atala, his portrait of Mademoiselle Mars; Massard's St. Cæcilia of Raphael, and Apollo with the Muses of Giulio Romano; Richomme's Dien's, Girodet's, Gudin's, Audouin's plates, no less magnificently than carefully executed; Jazet's large pieces in aquatinta (for instance, from the paintings of Vernet)—all manifest how rich France is in great engravers. Neither ought we to forget the magnificent literary works, almost constantly published in France, which owe their ornaments to the skill of French engravers.

In the most recent productions of the French engravers, an imitation of the school of Morghen is observable; whilst some young Italian and German artists have aimed at something higher than even Morghen's productions. Since the art of painting has ceased to produce many works worthy of multiplication by the burin of the first engravers, these have occupied themselves chiefly with ancient masterpieces, and engraving has taken a higher station among the fine arts. Morghen, the pupil of Volpato, and those who have followed him, have produced works before unequalled. The Milanese school of engravers, in particular, has reached a degree of perfection, through Anderloni and Longhi, which no other country can probably equal. Longhi's Sposalizio is as yet the greatest production in the art of engraving.

Toschi, of Parma, has acquired immortality by his Entrance of Henry IV. into Paris (from Gérard), in 1826; Schiavone, by his Ascension of the Holy Virgin (from the painting of Titian), which may be called perfect, in regard to its picture-like effect. Bettelini, Bonato, Gandolffi, Garavaglia, Fontana Rosapina, Benoglio, Giberti, Palmerini, Poporati, Pavon (by birth a Spaniard, however), Rainaldi and Rampoldi have produced beautifully finished engravings; and Luigi Rossini and Pinelli have etched scenes full of life. Splendid works, in which typography and chalcography unite their attractions, have appeared at Florence, Venice, Rome, and Milan. But England is richer in such works, as our topography forms a peculiar and very important branch of the productions of the art. Some of these works, however, exhibit an exaggerated delicacy, bordering on affectation; while others neglect details, and betray too much effort for effect. But the productions of Earlom, Pether, Dixon, Green, &c. must not be confounded with the works just referred to. The plates of Raphael's cartoons, in Hampton Court, on which Thomas Holloway and Webber were engaged, are praised as the highest specimens of the art. In these engravings, the masterly etching, which often permits them to allow the etchings themselves to remain, is worthy of admiration. Smith, Middiman, Byrne, James Mason, James and Charles Heath, William Woollet, William Sharp, John Burnet, and John Browne, are known to all collectors. Their works are, comparatively, seldom seen on the European continent, because of their high prices.

What Lasinio is for Italy, Moses aims to be for England, by his delicate sketches: among his other productions are his imitations of Retsch's illustrations of Göthe's Faust. But his copies of foreign masters are often deficient in correctness. Martin, Finden, Robinson, and Rolles deserve mention among distinguished English engravers.

With the Dutch, the burin is, at present, not very successful, if we compare their present artists to the former school of Pontius and Edelinck. But for picturesque etchings and productions by the needle, the skill formerly displayed has been preserved by Troostwyk Van Os, Overbeck, Jansen, Chalon, and others. For more highly finished productions, in which the burin and needle must unite, in order to produce a tone, as in the engravings of Rembrandt's pictures, Claessens and De Frey are acknowledged masters.—What Russia, Denmark, and the Netherlands have produced in this branch, is not unworthy of notice. The engravings of Switzerland, mostly in Aberli's manner, form a class by themselves.

In the United States, engraving has been cultivated with more success than any other department of the fine arts, though it cannot be expected that a country so young, and so distant from the numerous productions of former ages, should rival the great works of the art in Europe. But small engravings, particularly on steel, for souvenirs, have been produced, which may bear comparison with European productions of the kind. Among American engravers, Longacre, Kelly, Durandt, Danforth (now in London), Cheney, Gallaudet, Ellis, Hatch, and others, well deserve to be engaged on subjects of more permanent interest than souvenir engravings.

After the art of engraving in mezzotinto was introduced into England, by Prince Rupert, it was carried to much perfection. John Smith, who lived towards the end of the 17th century, has left more than 500 pieces in this style. He and George White formed a new epoch in the art, which the latter particularly improved, by first etching the plates, whereby they acquired more spirit. Of late years, many artists in England have devoted themselves to this branch: among these are M'Ardell, Honston, Earlom, Pether, Green, Watson, Dickinson, Dixon, Hudson, J. Smith, &c.

Enharmonic, in *music;* the epithet given by the ancient Greeks to that of their three genera, which consisted of quarter tones and major thirds. They, however, had originally another kind of enharmonic, more simple and easier of execution than this, and upon which the quarter tones or dieses were considered, by the theorists of the old school, as innovations too refined and artificial.

Ensemble. This term is used in the fine arts to denote the general effect of a whole work, without reference to the parts. Thus we speak of the *ensemble* of a picture, when we consider the effect of the whole representation on the mind of the spectator.—A thing may be excellent in its parts, as, for instance, a comedy, if the different characters are well drawn; yet it may be deficient in its *ensemble,* that is, as a whole. Rousseau uses this word, in the same meaning, in music; but, at present, *ensemble* is used for a composition of several voices, in which the chief voices are independent of each other, as the quintetts and finales in operas and oratorios.

Ensign. *Ensign-bearer,* commonly called *ensign,* is the lowest commissioned officer in the English army. In the French army under Napoleon, the oldest and most distinguished serjeants bore the colours. Napoleon ordered that those serjeants who could not write, and who had distinguished themselves, should be preferred, "because they could not be properly promoted farther, and yet deserved some distinction on account of their bravery." (See *Las Cases*).—In naval language, *ensign* is a large standard or banner, hoisted on a long pole, erected over the poop, and called the *ensign-staff.* It is more commonly called *flag.*

Entablature. In those buildings which are provided with columns, the entablature forms a continuous line immediately above the capitals, and it is frequently made the vehicle for very highly enriched ornaments.

Enteritis; inflammation of the intestines. It is known by the presence of fever, fixed pain in the abdomen, costiveness, and vomiting. The causes are acrid substances, indurated fæces, long-continued and obstinate costiveness, spasmodic cholic, and a stran-

gulation of any part of the intestinal canal; but another very general cause is, the application of cold to the lower extremities, or to the belly itself. It is a disease which is most apt to occur at an advanced period of life, and is very liable to a relapse. It comes on with an acute pain, extending, in general over the whole of the abdomen, but more especially round the navel, accompanied with eructations, sickness at the stomach, a vomiting of bilious matter, obstinate costiveness, thirst, heat, great anxiety, and a quick and hard, small pulse. After a short time, the pain becomes more severe, the bowels seem drawn together by a kind of spasm, the whole region of the abdomen is highly painful to the touch, and seems drawn together in lumpy contractions; invincible costiveness prevails, and the urine is voided with great difficulty and pain. The inflammation continuing to proceed with violence, terminates at last in gangrene; or, abating gradually, it goes off by resolution.

Enteritis is always attended with considerable danger, as it often terminates in gangrene, in the space of a few hours from its commencement. The treatment must be begun by taking blood freely from the arm, as far as the strength of the patient will allow; but, the disease occurring more frequently in persons rather advanced in years, and of a constitution somewhat impaired, it becomes more important to limit this evacuation, and rely, in a great measure, on the effects of a number of leeches applied to the abdomen. Another very useful step is, to put the patient into a hot bath, which may presently induce faintness; or, where this cannot be procured, fomenting the abdomen assiduously. When the symptoms are thus materially relieved, an ample blister should be applied. It becomes also, of the first importance to clear out the bowels. After the disease is removed, care should be taken to guard against accumulation of fæces, exposure to cold, or any thing else likely to occasion a relapse.

Epacts, in *chronology;* the excesses of the solar month above the lunar synodical month, and of the solar year above the lunar year of twelve synodical months; or of several solar months above as many synodical months, and several solar years above as many dozen of synodical months. The epacts, then, are either *annual* or *menstrual.*

Menstrual Epacts are the excesses of the civil or calendar month above the lunar month. Suppose, for example, it were new moon on the first day of January; since the lunar month is 29 days, 12 hours, 44 minutes, 3 seconds, and the month of January contains 31 days, the menstrual epact is 1 day, 11 hours, 15 minutes, 57 seconds.

Annual Epacts are the excesses of the solar year above the lunar. Hence, as the Julian solar year is 365 days, 6 hours, and the Julian lunar year 354 days, 8 hours, 48 minutes, 38 seconds, the annual epact will be 10 days, 21 hours, 11 minutes, 22 seconds, that is, nearly 11 days. Consequently, the epact of 2 years is 22 days; of 3 years, 33 days, or rather 30, since 30 days make an embolismic or intercalary month. Thus the epact of 4 years is 14 days, and so of the rest; and thus, every 19th year, the epact becomes 30, or 0; consequently, the 20th year, the epact is 11 again; and so the cycle of epacts expires with the golden number, or lunar cycle of 19 years, and begins with the same; these are Julian epacts: the Gregorian depend upon the same principles, allowing only for the difference of the respective years. As the new moons are the same, that is, as they fall on the same day after every 19 years, so the difference between the lunar and solar years is the same after every 19 years. And, because the said difference is always to be added to the lunar year, in order to adjust or make it equal to the solar year, therefore the said difference respectively belonging to each year of the moon's cycle, is called the *epact* of the said year, that is, the number to be added to the same year, to make it equal to the solar year.

Rule to find the Gregorian Epact. The difference between the Julian and Gregorian years being equal to the difference between the solar and lunar year, or 11 days, therefore the Gregorian epact for any year is the same with the Julian epact for the preceding year; and hence the Gregorian epact will be found by subtracting 1 from the golden number, multiplying the remainder by 11, and rejecting the 30's. This rule will serve till the year 1900; but, after that year, the Gregorian epact will be found by this rule: Divide the centuries of the given year by 4, multiply the remainder by 17; then to this product add 43 times the quotient, and also the number 86, and divide the whole sum by 25, reserving the quotient: next multiply the golden number by 11, and from the product subtract the reserved quotient, and the remainder, after rejecting all the 30's contained in it will be the epact sought. The following table contains the golden numbers, with their corresponding epacts, till the year 1900.

Table of Gregorian Epacts.

Golden Number	Epacts.	Golden Number.	Epacts.	Golden Number.	Epacts.
I.	0	VIII.	17	XV.	4
II.	11	IX.	28	XVI.	15
III.	22	X.	9	XVII.	26
IV.	3	XI.	20	XVIII.	7
V.	14	XII.	1	XIX.	18
VI.	25	XIII.	12	I.	0
VII.	6	XIV.	23		

Epaulement, in *fortification*, is a kind of breastwork, to cover the troops in front, and sometimes in flank. This term is frequently used for any work thrown up to defend the flank of a post, or any other place.

Epaulette (the French diminutive of *epaule*, shoulder) signifies a military ornament, worn on the shoulder. It originated in the time of Louis XIV. from the riband by which the belt sustaining the sword was kept from slipping from the shoulder. In some armies, every officer wears them, as in the Prussian; but there is a sufficient difference between those worn by different ranks, to enable a lieutenant or a captain to be distinguished immediately from a major or a colonel, and these again from the generals—a circumstance sometimes of great importance in battles. This means of distinction has this advantage, that it is not obvious to the enemy, as white plumes, &c., are. In the Russian and Prussian armies, every officer has two epaulettes; in the French army, this is not the case, but the shoulder on which the epaulette is worn distinguishes a captain or lieutenant. Many troops in the French

service wear woollen epaulettes; for instance, the grenadiers; and Napoleon thought them an efficient protection of the shoulder against the blows of swords. Many of his cavalry and infantry had epaulettes. Epaulettes have been introduced into the English navy, and, in our service, the following are the gradations of rank, as distinguished by them. Masters and commanders have one epaulette on the left shoulder; post-captains, under three years, one epaulette on the right shoulder, afterwards two epaulettes; rear-admirals have one star on the strap of the epaulette, vice-admirals two stars, and admirals three stars. Epaulettes are also worn by many civil officers on the continent of Europe, when in uniform.

EPHEMERIDES, in *astronomy;* tables calculated by astronomers, showing the present state of the heavens, for every day at noon; that is, the places wherein all the planets are found at that time. It is from these tables that the eclipses, conjunctions, and aspects of the planets are determined, horoscopes or celestial schemes constructed, &c.

EPICYCLE, in the ancient astronomy, was a subordinate orbit or circle, which was supposed to move on the circumference of a larger one, called the *different;* by means of which one motion, apparently irregular, was resolved into two that were circular and uniform. And, when the observed motion was so irregular and complicated as not to be resolved with one epicycle, others were added, till a nearer approximation was obtained. This system owed its origin to a prejudice that seems to have been extremely ancient, in favour of circular motion; and the problem that principally engaged the attention of astronomers, in those times, was to assign the proper proportion of the different and epicycle which should approximate nearest to absolute observation.

EPICYCLOID, in *geometry*, is a curve generated by a point in one circle which revolves about another circle, either on the concavity or convexity of its circumference, and thus differs from the common cycloid, which is generated by the revolution of a circle along a right line; though the latter has sometimes been assimilated with the former, by considering the right line as the circumference of a circle the diameter of which is infinite. The invention of epicycloids is ascribed to M. Roemer, the celebrated Danish astronomer.

EPIDEMIC, or EPIDEMIC DISEASE, signifies a state of sickness which prevails in a place or tract of country only for a temporary period. An epidemic always originates in transient external influences, which gradually produce such changes in the bodily system, as finally bring on the sickness. Thus many diseases appear to arise from some peculiar morbid matter in the atmosphere, brought by particular winds; e. g., the influenza, and other diseases: also poor or scanty food, unwholesome mixtures, &c., may occasion epidemics.

Seasons of scarcity, which compel men to have recourse to unusual means of subsistence (as, for example, in Norway and Sweden, to the bark of trees instead of corn), often occasion epidemics. The ergot in rye is supposed to be the cause of *raphania.* Bad barley, or much mixture of bearded darnel (*lolium temulentum*), makes the beer which is prepared from it unwholesome, and produces sickness in those who partake of it. Causes producing a disturbed state of mind, such as war, sieges, earthquakes, &c., by their effects on the nervous system, may very much favour the production of epidemic diseases, or, at least, render them more malignant.

Epidemics sometimes begin with a few, sometimes attack great numbers at once, as commonly happens in a great and sudden change of wind or weather. If, for instance, after a long continuance of a west or south-west wind, with warm weather, it suddenly changes to an east or north-east wind, we hear people complaining directly of coughs, colds, rheumatisms, &c. An epidemic, at its commencement, is usually mild, and becomes more dangerous as it spreads; as it goes off, it for the most part assumes a mild character again. It frequently terminates as gradually as it began, but sometimes suddenly. Many persons are not at all affected by the prevailing epidemic. The cause probably lies in their bodily habit, which is opposed to the prevailing influences, and makes them capable of resisting them longer than other persons. Thus it often happens that men with chronic complaints, hypochondriacs, &c., remain free from epidemic disorders.

Epidemics are often confounded with contagious disorders. The former originally are not contagious; their origin and propagation depend on general influences, and they commonly generate no contagious matter, producing the same disease in another body by contact with it. It is only in particular circumstances, especially if the disorder is a violent one and many patients are crowded into a narrow room, that a contagious matter can be generated, forming a corrupt atmosphere about the sick, and capable of exciting the disease in persons who come near it. Even under these circumstances, contagion does not necessarily take place, and the ignorant generally conceive a hasty and groundless fear of contagion. Thus, for instance, that is frequently ascribed to contagion which is only the consequence of a violent shock of the nervous system at the sight of a sick person, perhaps in a loathsome state, whereby the disease, to which the body was already disposed, is more quickly developed.

EPIDERMIS; the scarf-skin.

EPIGASTRIC. That part of the abdomen that lies over the stomach is called the *epigastric region.* It reaches from the pit of the stomach to an imaginary line above the navel, supposed to be drawn from one extremity of the last of the false ribs to the other.

EPIGLOTTIS; the cartilage at the root of the tongue that falls upon the glottis, or superior opening of the larynx; upper part of the windpipe. Its figure is nearly oval; it is concave posteriorly and convex anteriorly. Its apex or superior extremity is loose, and is always elevated upwards by its own elasticity. While the back of the tongue is drawn backwards in swallowing, the epiglottis is put over the aperture of the larynx; hence it shuts up the passage from the mouth into the larynx. The base of the epiglottis is fixed to the thyroid cartilage, the os hyoides, and the base of the tongue, by a strong ligament.

EPILEPSY; a nervous disease, depending on various causes, often exceedingly complicated, and incapable of being removed; hence so often an incurable periodical disease, appearing in single paroxysms. It, for the most part, is preceded by a cold vapour creeping up from the foot or hand to the breast and head; but sometimes there are no precursive symptoms. The patient suddenly falls, commonly with a cry, the thumbs are convulsed, other parts are agitated more or less entire insensibility succeeds, the breath is

short and quick, broken, and accompanied with groans, the mouth foams, the face is convulsed, the teeth gnash together, the eyes are distorted, the urine and other evacuations are discharged involuntarily, the eyes are wide open and staring, and insensible to the light. The paroxysm is usually over in ten or twenty minutes. The patient awakes as from a deep sleep, entirely unconscious of what has passed; he feels nothing unpleasant, except fatigue, and a little pain in his limbs. Sometimes the paroxysms occur nine or ten times in an hour, or oftener; sometimes only once a month, at the change of the moon, or every six months, or at still longer periods. During the paroxysm, all that is to be attended to is to prevent the patient from injuring himself. All other attempts, such as forcing open the thumbs, and the like, are of no avail, except to terminate the paroxysm sooner, but, at the same time, occasion a quicker return of it, and render the disease more difficult to cure.

Eprouvette; the name of an instrument for ascertaining the strength of fired gunpowder, or for comparing the strength of different kinds of gunpowder. One of the best, for the proof of powder in artillery, is that contrived by Dr. Hutton. It consists of a small brass gun, about 2½ feet long, suspended by a metallic stem, or rod, turning by an axis on a firm and strong frame, by means of which the piece oscillates in a circular arch. A little below the axis, the stem divides into two branches, reaching down to the gun, to which the lower ends of the branches are fixed, the one near the muzzle, the other near the breech of the piece. The upper end of the stem is firmly attached to the axis, which turns very freely by its extremities in the sockets of the supporting frame, by which means the gun and stem vibrate together in a vertical plane, with a very small degree of friction. The piece is charged with a small quantity of powder (usually about two ounces), without any ball, and then fired; by the force of the explosion the piece is made to recoil or vibrate, describing an arch or angle, which will be greater or less according to the quantity or strength of the powder.

Epsom Salt (sulphate of magnesia, cathartic salt) appears in capillary fibres or acicular crystals; sometimes presents prismatic crystals. The fibres are sometimes collected into masses; and it also occurs in a loose, mealy powder; its colour is white, grayish, or yellowish; it is transparent, or translucent, with a saltish, bitter taste. It is soluble in its own weight of cold water, and effloresces on exposure to the air. It is composed of water, sulphuric acid, and magnesia. It is found covering the crevices of rocks, in caverns, old pits, &c., in the vicinity of Jena, on the Harz, in Bohemia, &c., in mineral springs, in several lakes in Asia, and in sea-water. It is obtained for use from these sources, or by artificial processes, and is employed in medicine as a purgative. The English name is derived from the circumstance of its having been first procured from the mineral waters at Epsom. A person of the name of Grisenthwaite has taken out a patent for this medicine. The new process by which Epsom salts are to be produced is by mixing together magnesia, sulphate of lime, or plaster of Paris, with carbonic acid and water, which will form a sulphate of magnesia. The magnesia is to be obtained either by precipitation from sea-water, or by the common earthy precipitations, or from the magnesian limestone. The same modes of evaporation and crystallization are to be employed as are usually practised by chemists. The patentee claims to be the first who has used sulphate of lime, and carbonic acid, for the production of the above salt. (See Magnesia.)

Equation, in *algebra*, is the expression of the equality of different indications of the same magnitude; as, for instance, 9 and 2 are equal to 11, in mathematical characters is expressed thus:—$9+2=11$; or, 3 from 4 leave 1, is $4-3=1$. An equation may contain known quantites and unknown quantities. The latter are usually indicated by the last letters of the alphabet; and it is one of the main objects of mathematics to reduce all questions to equations, and to find the value of the unknown quantities by the known, which is sometimes a difficult, but, at the same time, interesting operation; because x, or the unknown quantity, may be given under so involved a form as to require the greatest tact to determine its value. The work of Meier Hirsch, already mentioned in a previous article is, perhaps, the best collection of equations for solution. There must always be as many equations as there are unknown quantities; and it is not always easy to form these from the question proposed. The equation is called *simple, quadratic, cubic, bicubic, of the fifth*, &c. *degree*, according to the exponent of the unknown quantity; for instance $(x^2-4cdy+xp)\,x^4=pq-\sin 4p$, is an equation of the sixth degree.

Equation of Payments, in *arithmetic*, is the finding the time to pay at once several debts due at different times, and bearing no interest till after the time of payment, so that no loss shall be sustained by either party. The rule commonly given for this purpose is as follows:—Multiply each sum by the time at which it is due; then divide the sum of the products by the sum of the payments, and the quotient will be the time required. Thus, for example, A owes B 190*l*., to be paid as follows; viz. 50*l*. at 6 months, 60*l*. at 7 months, and 80*l*. at 10 months: what is the equated time at which the whole ought to be paid, that no loss may arise, either to debtor or creditor? By the rule,

$$\begin{array}{rl} 50 \times 6 = & 300 \\ 60 \times 7 = & 420 \\ 80 \times 10 = & 800 \\ \hline 190 \quad) & 1520 \ (8 \text{ months, equat.} \\ & 1520 \quad \text{time.} \end{array}$$

This rule, however, is founded on a supposition that the interest of the several debts which are payable before the equated time, from their terms to that time, ought to be equal to the sum of the interest of the debts payable after the equated time, from that time to their terms respectively, which, however, is not correct, as it is the discount that is to be considered, and not the interest, in the latter sums. In most cases, however, that occur in business, the error is so trifling, that the popular rule will probably always be made use of, as being by far the most eligible and expeditious method that we could suggest.

Equation of Time, in *astronomy*, derotes the difference between mean and apparent time, or the reduction of the apparent unequal time, or motion of the sun or a planet, to equable and mean time or motion. If the earth had only a diurnal motion, without an annual, any given meridian would revolve from the sun to the sun again in the same space of time as from any star to the same star again,

because the sun would never change his place with respect to the stars. But as the earth advances almost a degree eastward in its orbit in the time that it turns eastward round its axis, whatever star passes over the meridian on any day with the sun, will pass over the same meridian on the next day, when the sun is almost a degree short of it, that is, 3 minutes, 56 seconds sooner. If the year contained only 360 days, as the ecliptic does 360 degrees, the sun's apparent place, so far as his motion is equable, would change a degree every day, and then the sidereal days would be 4 minutes shorter than the solar. The mean and apparent solar days are never equal, except when the sun's daily motion in right ascension is 59″; which is nearly the case about the 15th of April, the 15th of June, the 1st of September, and 24th of December, when the equator is 0′, or nearly so; and it is at its greatest about the 1st of November, when it is 16′ 14″.

EQUATOR. By the celelestial equator is understood that imaginary great circle in the heavens, the plane of which is perpendicular to the axis of the earth; it is every where 90° distant from the poles of the earth, which are therefore its poles, and its axis is the axis of the earth. It divides the celestial sphere into the northern and southern hemispheres. During his apparent yearly course, the sun is twice in the equator, at the beginning of spring and of autumn. Then the day and night are equal,—whence the name of *equator*. The situation of the stars, with respect to the equator, is determined by their declension and right ascension. The equator, or equinoctial, called by mariners simply the *line*, is that great circle of our globe, every point of which is 90 degrees from the poles, which are also its poles, and its axis is the axis of the earth. It is in the plane of the celestial equator. All places which are on it, have invariably equal days and nights. (See DAY.) Our earth is divided by it into the northern and southern hemispheres. The diurnal revolution of the earth is in the direction of it. It crosses the centre of Africa, the islands of Sumatra, Borneo, Celebes. &c., in Asia, then traverses the Pacific ocean, and crosses South America, in Colombia, thence proceeds through the Atlantic back to Africa. To cross the line, in navigation, is to pass over the equator. The equatorial regions are subject to long calms, alternating with frightful hurricanes.

As equal or mean time is estimated by the passage of arcs of the equator over the meridian, it frequently becomes necessary to convert parts of the equator into time, and the converse, which is performed by the following analogy, viz.—as 15° : 1 hour : : any arc of the equator : the time it has been in passing. Or, conversely, 1 hour : 15° : . any given time : to the arc of the equator.—From this circle is reckoned the latitude of places, both north and south, in degrees of the meridian. (See LATITUDE and LONGITUDE.)

EQUATORIAL, UNIVERSAL, or PORTABLE OBSERVATORY, is an instrument intended to answer a number of useful purposes in practical astronomy, independent of any particular observatory. It may be employed in any steady room or place, for performing many useful problems. (See ASTRONOMY.)

EQUINOCTIAL, in *astronomy;* a great circle of the sphere, under which the equator moves in its diurnal motion. It is the same as the *celestial equator.* (See EQUATOR.)

EQUINOCTIAL GALES; storms which are observed generally to take place about the time of the sun's crossing the equator or equinoctial line, at which time there is equal day and night throughout the world.

EQUINOCTIAL POINTS are the two points wherein the equator and ecliptic intersect each other: the one, being in the first point of Aries, is called the *vernal* point; and the other, in the first point of Libra, the *autumnal* point.

EQUINOX is that time of the year when the day and night are equal: the length of the day is then 12 hours; the sun is ascending 6 hours, and descending the same time. This is the case twice a year, in the spring and in autumn, when the sun is on the equator. When the sun is in this situation, the horizon of every place is, of course, divided into two equal parts by the circle bounding light and darkness; hence the sun is visible every where 12 hours, and invisible for the same time in each 24 hours. (See DAY.) The vernal equinox marks the beginning of spring, the autumnal that of autumn: at all other times, the lengths of the day and of the night are unequal, and their difference is the greater the more we approach either pole, and in the same latitude it is every where the same. Under the line, this inequality entirely vanishes: there, during the day, which is equal to the night, the sun always ascends 6 hours, and descends 6 hours. In the opposite hemisphere of our earth, the inequality of the days increases in proportion to the latitude: the days increase there, while they diminish with us, and *vice versâ*. The points where the ecliptic comes in contact with the equator are called *equinoctial* points.

The vernal equinoctial point was formerly at the entrance of the constellation of Aries; hence the next 30 degrees of the ecliptic, reckoned eastward from it, have been called *Aries;* but this point long ago deserted the constellation of Aries, and now stands under Pisces; for it is found by observation, that the equinoctial points of the ecliptic are continually moving backward, or westward; which retrograde motion of the equinoctial points is what is called the *precession of the equinoxes*. (See PRECESSION.) It appears from the result of calculations, that the path of either of the poles is a circle, the poles of which coincide with those of the ecliptic, and that the pole will move along that circle so slowly as to accomplish the whole revolution in about 25,791 years, nearly. The diameter of this circle is equal to twice the inclination of the ecliptic to the equator, or about 47 degrees. Now, as the ecliptic is a fixed circle in the heavens, but the equator, which must be equidistant from the poles, moves with the poles, therefore the equator must be constantly changing its intersection with the ecliptic. And from the best observations, it appears, that the equator cuts the ecliptic every year 50 seconds .25, more to the westward than it did the year before; hence, the sun's arrival at the equinoctial point precedes its arrival at the same fixed point of the heavens every year, by 20 minutes 23 seconds of time, or by an arc of 50 seconds .25.—Thus, by little and little, these equinoctial points will cut the ecliptic more and more to the westward, till, after 25,791 years, they return to the same point.

ERGOT is an important article in *materia medica;* has been found capable of exerting a very powerful

and specific action upon the uterus, and is administered in small doses in certain extreme cases.

Ermine, in *commerce;* a species of fur which produces a very high price. The finest comes from Asia, and a dress frequently costs from one to two hundred pounds.

Eruption, in *medicine;* a sudden and copious excretion of humours, and the same with *exanthema*, or breaking out; as the pustules of the plague, small-pox, measles, &c.

Erysipelas. This disease is an inflammatory affection, principally of the skin, when it makes its appearance externally, and of the mucous membrane, when it is seated internally; and is more liable to attack women and children, and those of an irritable habit, than those of a plethoric and robust constitution. Erysipelas sometimes returns periodically, attacking the patient once or twice a year, or even once every month; and then, by its repeated attacks, it often gradually exhausts the strength, especially if the patient be old and of a bad habit. Every part of the body is equally liable to it; but it more frequently appears on the face, legs, and feet, than any where else, when seated externally. It is brought on by all the causes that are apt to excite inflammation, such as injuries of all kinds, the external application of stimulants, exposure to cold, and obstructed perspiration; and it may likewise be occasioned by a certain matter generated within the body, and thrown out on its surface. A particular state of the atmosphere seems sometimes to render it epidemical. A species of erysipelatous inflammation, which most usually attacks the trunk of the body, is that vulgarly known by the name of *shingles*, being a corruption of the French word *ceingle*, which implies a belt. Instead of appearing a uniform inflamed surface, it consists of a number of little pimples extending round the body a little above the *umbilicus*, which have vesicles formed on them in a short time. Little or no danger ever attends this species of erysipelas.

Escalade, in *war;* a furious attack of a wall or a rampart, carried on with ladders, to pass the ditch or mount the rampart, without proceeding in form, breaking ground, or carrying on regular works to secure the men.

Escapement; that portion of a clock which, by giving motion to the pendulum, serves to regulate the operations of the wheel-work. It consists of the pallets, swing-wheel, and crutch: the latter connects the escapement with the pendulum. Under the article Watch, the various species of escapement belonging to that machine will be described.

Escutcheon, in *heraldry*, is derived from the the French *écusson*, and that from the Latin *scutum*. It signifies the shield whereon coats of arms are represented.

Esplanade, in *fortification;* the sloping of the parapet of the covered way towards the open country; the same with *glacis*.

Esquire; anciently, the person that attended a knight in the time of war, and carried his shield. Those to whom the title of *esquire* is now due in England, are, all noblemen's younger sons, and the eldest sons of such younger sons; the eldest sons of knights, and their eldest sons; the officers of the king's court, and of his household; counsellors at law, justices of the peace, &c., though the latter are only esquires in reputation: besides, a justice of the peace holds this title no longer than he is in commission, in case he is not otherwise qualified to bear it; but a sheriff of a county, who is a superior officer, retains the title of *esquire* during life, in consequence of the trust once reposed in him. The heads of some ancient families are esquires by right of prescription.

Essential Oils. This name is applied to those volatile fluids usually obtained from aromatic plants, by subjecting them to distillation with water. The oil is volatilized with the aqueous vapour, and is easily condensed; a small portion of it is retained in solution by the water; but the greater part separates, and is obtained pure from the difference in their specific gravity. In some instances, as, for example, in the rind of the orange and lemon, the oil exists in distinct vesicles, and may be obtained by expression.

The principal volatile or essential oils are those of turpentine, aniseed, nutmeg, lavender, cloves, caraway, peppermint, spearmint, sassafras, camomile, and citron. The taste of those oils is acrid and burning; and their odour very pungent, generally resembling the taste and smell of the vegetables affording them. They are generally fluid, and remain so even at a low temperature; but some congeal at a very moderate degree of cold, and others are naturally concrete. They are extremely volatile, and boil at a temperature considerably above that of boiling water; thus oil of turpentine boils at 315°. They are very soluble in strong alcohol, but, on adding water largely, are precipitated. They are soluble in ether in like manner, but do not form soaps with the alkalies, by which they are distinguished from the fixed oils. They are readily inflamed by strong nitric acid; especially with the precaution of adding a little sulphuric acid to render the former more concentrated. Exposed to the action of the air, they undergo an alteration in consequence of the absorption of oxygen, become thickened, and gradually change into a solid matter, resembling the true resins. When digested with sulphur, they unite with it, forming what have been called *balsams of sulphur*.

One of the most useful and abundant of the essential oils is that of turpentine, commonly called *spirit of turpentine*. It is obtained by distilling turpentine and water, in due proportions, from a copper alembic. It is perfectly limpid and colourless, has a strong smell, a bitterish taste, boils at 315°, and is extremely inflammable. It is the solvent employed in making a variety of varnishes; but for purposes of nicety, it requires to be rectified by a second distillation. In general, the volatile oils are used in the practice of medicine, or as perfumes. Those applied to the latter use, as the essence of rose, of jasmine, violet, &c., are possessed of a more feeble odour, and, being obtained from the flowers of their respective plants, require much care in their preparation. This is done by spreading upon white wool, impregnated with olive oil, the petals of the flowers, and leaving them for some time, covered over with a woollen cloth, upon which flowers are also scattered. The flowers are renewed from time to time, until the olive oil employed appears to be saturated with the oil of the flowers, when this last is separated by digesting the wool in alcohol.

Ether; a very subtle fluid. As the class of bodies known under this name are of great importance in chemistry, we may notice them somewhat in detail. They differ in their qualities as produced by different acids; but they agree in the possession of certain

general properties; they are highly volatile, odorous, pungent, and inflammable; miscible with water, and capaple of combination with alcohol in every proportion.

Sulphuric ether, produced by the action of sulphuric acid on alcohol, is the one which has been longest known to chemists. To prepare sulphuric ether, sulphuric acid is poured on an equal weight of alcohol in a retort; and, after they are thoroughly mixed by gradual agitation, heat is applied by the medium of a sand-bath, a large receiver being adapted to the retort, carefully luted, and kept cool by water. Distillation commences when the temperature is raised to 208°, and a colourless liquid condenses in the receiver. When it amounts to about half the quantity of alcohol that had been employed, the heat is withdrawn. The residual liquid is of a dark brown or black colour. If a fresh portion of alcohol, not more than half of the first quantity, be added to it when it is cold, an additional portion of ether will be procured by a new distillation.

The ether condensed in the receiver by this process, is weak from the intermixture of water, and is usually also impure from the presence of a portion of sulphurous acid. It is rectified by agitating it with subcarbonate of potash, or muriate of lime, and distilling it a second time by a very gentle heat, putting into the retort from which it is distilled a small quantity of black oxide of manganese.

Sulphuric ether is a fluid extremely light; its specific gravity, when it is highly rectified, being so low as .716. It is colourless and transparent, has a pungent taste, and a penetrating, rather fragrant odour. It is highly volatile, evaporating rapidly at natural temperatures. It boils under the usual atmospheric pressure at 98°, and, *in vacuo*, at a temperature even below 32°. In its spontaneous evaporation, it absorbs a considerabte quantity of caloric, so as to produce much cold. It congeals at 47°. It is inflammable, burns with a clear white flame, and without smoke, producing by its combustion water and carbonic acid. Its vapour, diffused in atmospheric air or oxygen gas, explodes when kindled.

Sulphuric ether is soluble in water, requiring about 10 parts for its solution. It dissolves in alcohol in every proportion. On the fixed alkalies or earths it exerts no action; with ammonia it combines by distillation. It dissolves sulphur and phosphorus in small proportions; and it resembles alcohol in the solvent operation it exerts on a number of the vegetable proximate principles.

Nitric ether is formed by the action of nictric acid on alcohol; but, from the violence of this action, the process is difficult, and requires to be conducted with much caution. Various methods have been employed; that of Woolfe is generally preferred. It consists in adding to four parts of nitre in coarse powder in a retort, a mixture, in successive small portions, of four parts of sulphuric acid, and rather more than three parts of alcohol, connecting the retort with a range of receivers, kept cool; nitric ether is formed and volatilized without the application of heat, and is condensed by passing the gaseous product through water, or through a solution of muriate of soda in the receivers. It floats above the liquor, and is purified from any free acid by agitation with lime, and a second distillation with a gentle heat.

Nitric ether has an odour strong, but less fragrant than that of sulphuric ether; it is light, volatile, and inflammable. When pure and highly rectified, its levity is such that it floats on water; and its volatility is so great that it instantly evaporates when poured from a bottle, and it boils at 70°, under the usual atmospheric pressure; it requires 50 parts of water for its solution, but combines with alcohol in every proportion. (See PHOSPHORIC and MURIATIC ETHER.)

ETCHING ON GLASS. The process of etching as applied to copperplate *engraving*, will be found under that article; but that which is effected by fluoric acid on glass, is so curious as to deserve a particular description. The original invention of this beautiful art appears to belong to the beginning of the last century. In an old German work, entitled *Breslawer's Collections*, is the following notice:—"The discovery of a powerful acid, by means of which every imaginable kind of figures may easily be etched upon glass. Take spiritus nitri per distillationem, put it into a retort, and apply a strong heat. When it has passed over into the receiver, throw into it some powdered green Bohemian emerald (which, when heated, shines in the dark), otherwise called phosphrous.—This being done, place the receiver, containing the mixture, on a heated sand-bath, for about four-and-twenty hours, and it will be fit for the purpose. To use this corrossive acid, take a pane of glass of any kind, clean it well, and free it from grease, by washing it with ley, and, when dry, trace out upon it, with sulphur and varnish, whatever you choose. Put a border of bees-wax round it, about an inch high, and then pour the corrossive acid, prepared as before directed, carefully over the whole surface of the glass, and let it stand undisturbed for some time—the longer the better. The glass will become corroded, and all you have traced before will now appear as if raised or elevated above the surface of the glass, in a very distinct and pleasing manner." (See FLUORIC ACID.)

EUCHLORINE. This gas was discovered in 1811, by Sir H. Davy, and described by him in the *Philosophical Transactions* for that year under this name. It is made by the action of muriatic acid on chlorate of potash; and its production is explicable by the fact, that muriatic and chloric acids mutually decompose each other. When muriatic acid and chlorate of potash are mixed together, part of the muriatic acid unites with the potash of the salt, and thus sets chloric acid free, which instantly re-acts on the free muriatic acid. The result of the re-action depends on the relative quantity of the substances. If chlorate of potash be mixed with excess of concentrated muriatic acid, the chloric acid undergoes complete decomposition. The best proportion of the ingredients is two parts of chlorate of potash, one of strong muriatic acid, and one of water; and the re-action of the materials should be promoted by heat sufficient to produce moderate effervescence. The gases should be collected over mercury, which combines with the chlorine, and leaves the protoxide of chlorine in a pure state. Protoxide of chlorine has a yellowish green colour, similar to that of chlorine, but considerably more brilliant, which induced Sir H. Davy to give it the name of *euchlorine*. Its odour is like that of burnt sugar. Water dissolves eight or ten times its volume of the gas, and acquires a colour approaching to orange. It bleaches vegetable substances, but gives the blue colours a tint of red before destroying them. It does not unite with alkalies, and therefore is not an acid. It is explosive in a high degree. Protoxide of chlorine is easily ana-

lyzed by heating a known quantity of it in a strong tube over mercury. An explosion takes place; and 50 measures of the gas expand to 60 measures, of which 20 are oxygen, about 40 chlorine.

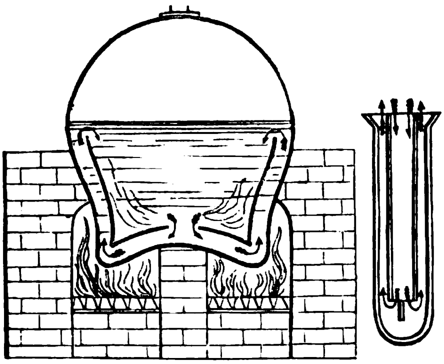
Eudiometer; an instrument for ascertaining the purity of air, or, rather, the quantity of oxygen contained in any given bulk of elastic fluid. Dr. Priestley's discovery of the great readiness with which nitrous gas combines with oxygen, and is precipitated in the form of nitric acid, was the basis upon which he constructed the first instrument of this kind. It consisted of a glass vessel, containing an ounce by measure. This was filled with the air to be examined, which was transferred from it to a jar, of an inch and a half diameter inverted in water; an equal measure of fresh nitrous gas was added to it, and the mixture was allowed to stand two minutes. If the absorption were very considerable, more nitrous gas was was added, till all the oxygen appeared to be absorbed. The residual gas was then transferred into a glass tube, two feet long and one-third of an inch wide, graduated to tenths and hundredths of an ounce measure; and thus the quantity of oxygen absorbed was measured by the diminution that had taken place. Other eudiometrical methods were employed by other chemists. Volta had recourse to the detonation of air with hydrogen gas. For this purpose, two measures of hydrogen gas are introduced into a graduated tube, with three of the air to be examined, and fired by the electric spark. The diminution of bulk observed after the vessel had returned to its original temperature, divided by three, gives the quantity of oxygen consumed. The action of liquor prepared from sulphur and potash, or sulphur and lime, boiled in water, and the slow combustion of phosphorus, have, likewise, been employed in eudiometry. Dobereiner has suggested the use of little balls of spongy platina, for the purpose of detecting minute portions of oxygen in a gaseous mixture, in which hydrogen is also present. Its effect is immediate and complete. The moment the substance rises above the surface of the mercury, in the tube containing the mixture, the combination of the oxygen and hydrogen begins, and in a few minutes is completed. So energetic is it in its action, that it enables hydrogen to take 1 of oxygen from 99 of nitrogen. See the various gases in their alphabetical order.

Evaporation is the conversion of liquid and solid bodies into elastic fluids, by the influence of caloric. Expose, for instance, water to heat, bubbles at first adhere to the sides of the vessel, which, by degrees, ascend to the surface, and burst. These bubbles rise the more rapidly in proportion to the heat. Water is evaporated by the heat of the sun merely, and even without this in the open air, and the vapour, rising into the air, is condensed into clouds. The general cause of evaporation is caloric; but different substances require different degrees of it. Water is particularly subject to evaporation. It evaporates at a very low temperature, and, from the immense quantity which is spread over the earth, it may be inferred, with great probability, that the most important changes in our atmosphere are occasioned by it. Instruments have been invented to measure the evaporation of water (see Hygrometry), but the results are uncertain. If we assume, as experiments justify, that the annual evaporation averages 30 inches (i. e. that the vapour, if reconverted into water, would cover the surface from which the evaporation took place, to a height of 30 inches), then, the surface of all the waters on our earth being assumed at 128,000,000 of geographical miles, 60,000 cubic miles of water would be annually changed into vapour; and the amount will be still greater, if we add to it the evaporation from moist earth and from the watery parts of the vegetable and animal kingdoms. In summer, evaporation is generally much greater than in winter; yet it is not so inconsiderable in cold weather as we might suppose from the small quantity of caloric then sensible. Even in the polar circles, it does not entirely cease; for ice evaporates in the open air. To account for the phenomenon of evaporation, two hypotheses have been formed; that it is a conversion of fluids into elastic vapour by their union with caloric, or that it is a real solution of the fluids in the air. The latter theory has been opposed, particularly by De Luc. He maintains that, in evaporation, water combines with caloric, without being dissolved in the air. The principal argument in support of this theory is, that cold is generated by the evaporation of a liquid. Cold is only the absence or consumption of caloric. If now, in evaporation, caloric is consumed, i. e. is combined with the evaporated water, this consumption must generate a sensible cold. De Luc farther maintains, that the air, so far from contributing to evaporation, prevents it by pressure. If this pressure is removed, the same quantity of water requires far less caloric to evaporate it; for experiments show that water evaporates more rapidly in a vacuum than in the air, and Saussure says, that at the same degree of the thermometer and hygrometer, the evaporation on mountains, where the air is of three times less density, is more than double that in the valleys. Later experiments render it still more evident that a dissolving power of air is not necessary to change water into an elastic vapour, since, otherwise, it could not be produced in a vacuum. Such a dissolving power in the air, however, is absolutely required to effect a uniform mixture of this vapour with air; otherwise, from the difference of the specific gravities of the two fluids, a separation must ensue, of which we have no experience; and we find ourselves compelled to regard the union of the expansive vapour with the air as a true solution of the one in the other. (See Perspiration.)

Artificial Evaporation is a chemical process, usually performed by applying heat to any compound substance, in order to separate the volatile parts. It differs from distillation, its object being chiefly to preserve the more fixed matters, while the volatile substances are allowed to escape. Accordingly, the vessels in which these two operations are performed are different; evaporation being commonly made to take place in open, shallow vessels, and distillation in an apparatus nearly closed from the external air.

There is a most important improvement in the process of artificial evaporation, which must be noticed here. We are indebted to Mr. Perkins for this discovery, which is now in operation on one of the large rail roads, and, as it is the subject of a patent, the apparatus may be thus briefly described: It consists of a boiler furnished with a casing, or inner boiler. On applying fire beneath, the vapour rises, carrying with it a considerable portion of the water. The power of the current to put in motion other bodies is most extraordinary—masses of sand, and even flint stones, are by this means driven along in rapid succession.

The direction of the current is shown in the engraving by that of the arrows.



The same is seen to occur in the case of the tubular boiler shown in the narrow section. Now one of the principal advantages is, that this species of boiler requires less fuel, as all the caloric is at once absorbed by the water. And another, and scarcely less important advantage, is found to arise from the boiler needing no cleaning, as the constant circulation, like that of the veins and arteries in the human body, keeps the whole of the surfaces in a clear state.

EXANTHEMATA; diseases of the skin, joined with fever, hence called *acute*, *hot* eruptions, to distinguish them from *chronical* eruptions, which are only incidentally accompanied with fever (called, in medical language, *impetigines*.) They include the small-pox, measles, scarlet-fever, rash, &c. Each has its peculiarities, relating to the manner of its origin, to the form and position of the eruption, and to the continuance of the disorder. (See SMALL-POX, &c.)

EXCISE DUTY; an impost laid on various commodities as they are consumed in retail. As a great change is promised, and likely to take place in the laws which now place every dealer in exciseable articles under the inquisitorial powers of the servants connected with this branch of the revenue, we purpose entering fully into the subject under TAXATION.

EXPANSION, in *physics*, is the enlargement or increase in the bulk of bodies, in consequence of a change in their temperature. This is one of the most general effects of heat, being common to all bodies whatever, whether solid or fluid. The expansion of solid bodies is determined by the pyrometer, and that of fluids by the thermometer. (See those articles.) The expansion of fluids varies considerably; but, in general, the denser the fluid, the less the expansion; thus water expands more than mercury; and spirits of wine more than water; and, commonly, the greater the heat, the greater the expansion; but this is not universal, for there are cases in which expansion is produced, not by an increase, but by a diminuation of temperature. Water furnishes us with the most remarkable instance of this kind. Its maximum of density corresponds with 42°.5, of Fahrenheit's thermometer; when cooled down below 42°.5 it undergoes an expansion for every degree of temperature which it loses; and at 32°, the expansion amounts to $\frac{1}{160}$ of the whole expansion which water undergoes when heated from 42°.5 to 212°. With this more recent experiments coincide very nearly; for, by cooling 100,000 parts in bulk of water from 42°.5 to 32°, they were converted to 100,031 parts.

The expansion of water is the same for any number of degrees above or below the maximum of density. Thus, if we heat water 10° above 42°.5, it occupies precisely the same bulk as it does when cooled down to 10 degrees below 42°.5. Therefore the density of water at 32° and at 53° is precisely the same. Dalton cooled water to the temperature of 5° without freezing, or 37°.5 below the maximum point of density; and, during the whole of that range, its bulk precisely corresponds with the bulk of water the same number of degrees above 42°.5. The prodigious force with which water expands in the act of freezing, is shown by glass bottles filled with water, which are commonly broken in pieces when the water freezes. A brass globe, whose cavity is an inch in diameter, may be burst by filling it with water and freezing it; and the force necessary for this effect is 27,720 lbs. weight. The expansive force of freezing water may be explained by supposing it the consequence of a tendency which water, in consolidating, is observed to have to arrange its particles in one determinate manner, so as to form prismatic crystals, crossing each other at angles of 60° and 120°. The force with which they arrange themselves in this manner must be enormous, since it enables small quantities of water to overcome so great mechanical pressures. This observation is conspicuously illustrated by observing the crystals of ice on a piece of water exposed to the action of the air in frosty weather; or upon a pane of glass in a window of a room without a fire, at the same season. Various methods have been tried to ascertain the specific gravity of ice at 32°; that which succeeded best was to dilute spirits of wine with water till a mass of solid ice put into it remained in any part of the liquid without sinking or rising. The specific gravity of such a liquid is 0.92, which, of course, is the specific gravity of ice, supposing the specific gravity of water at 60° to be 1. This is an expansion much greater than water experiences even when heated to 212°, its boiling point. We see from this that water, when converted into ice, no longer observes that equable expansion measured by Dalton, but undergoes a very rapid and considerable augmentation of bulk.

EXPECTORANTS, in *pharmacy*; medicines which promote expectoration. Such are the stimulating gums and resins, squills, &c.

EXPECTORATION; the act of evacuating, or bringing up phlegm, or other matters, out of the trachea and lungs, by coughing, &c.

EXPERIMENTAL PHILOSOPHY is that which deduces the laws of nature, the properties and powers of bodies, and their actions upon each other, from sensible experiments and observations. In our inquiries into nature, we are to be guided by those rules and maxims which are found genuine, and consonant to a just method of physical reasoning; and these rules are, by Sir Isaac Newton, reckoned four, viz. First. More causes of natural things are not to be admitted than are true, and sufficient to explain the phenomena; for nature is simple, and does nothing in vain. Second. Therefore, of natural effects of the same kind, the same causes are to be assigned, as far as it can be done; as of respiration in man and beasts, of the descent of stones in Europe and America, of light in a culinary fire and in the sun, and of the reflection of light in the earth and

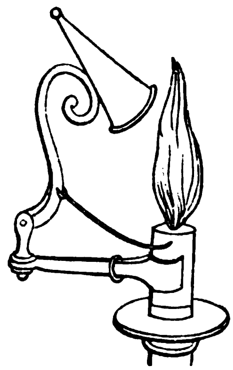
the other planets. Third. The qualities of natural bodies, which cannot be increased or diminished, and agree to all bodies on which experiments can be made, are to be reckoned as the qualities of all bodies whatever; thus, because extension, divisibility, hardness, impenetrability, mobility, the *vis inertiæ*, and gravity, are found in all bodies under our inspection, we may conclude that they belong to all bodies whatever, and are the original and universal properties of them. Fourth. In experimental philosophy, propositions collected from the phenomena by induction, are to be deemed (notwithstanding contrary hypotheses) either exactly, or very nearly true, till other phenomena occur, by which they may be rendered more accurate, or liable to exception. This ought to be done, lest arguments of induction should be destroyed by hypotheses, and logical series be superseded by conjectures.

EXPLOSION, in *natural philosophy;* a sudden and violent expansion of an aërial or other elastic fluid, by which it instantly throws off any obstacle in its way. Explosion differs from expansion in this,—that the latter is a gradual power, acting uniformly for some time, whereas the former is momentary. The expansions of solid substances do not terminate in violent explosions, on account of their slowness, and the small space through which the expanding substance moves. Thus we find, that, though wedges of wood, when wetted, will cleave solid blocks of stone, they never throw them to any distance, as gunpowder does. On the other hand, it is seldom that the expansion of any elastic fluid bursts a solid substance, without throwing the fragments of it to a considerable distance. The reasons of this may be comprised in these particulars: First. The immense velocity with which the aërial fluids expand, when affected by a considerable degree of heat. Second. Their celerity in acquiring heat, and being affected by it, which is much superior to that of solid substances. Thus air, heated as much as iron when brought to a white heat, is expanded to four times its bulk; but the metal itself will not be expanded the 500th part of that space. In the case of gunpowder, the velocity with which the flame moves is calculated, by Mr. Robins, to be no less than 7000 feet in a second, or little less than 70 miles per minute. Hence the impulse of the fluid is inconceivably great, and the obstacles on which it strikes are carried off with vast velocity, though much less than that just mentioned; for a cannon-ball, with the greatest charge of powder, does not move at a greater rate than 2400 feet per second, or little more than 27 miles per minute. The velocity of the ball again is promoted by the sudden propagation of the heat through the whole body of the air, as soon as it is extricated from the materials of which the gunpowder is made, so that it is enabled to strike all at once, and thus greatly to augment the movements of the ball. We may conclude, upon these principles, that the force of an explosion depends, first, on the quantity of elastic fluid to be expended; second, on the velocity it acquires by a certain degree of heat; and, third, on the celerity with which the degree of heat affects the whole of the expansile fluid. These three take place in the greatest perfection where the electric fluid is concerned, as in lightning, earthquakes, and volcanoes. (See STEAM).

EXPONENT, in *mathematics*, is the index of a root or power. For instance, if a quantity is multiplied by itself any number of times, instead of repeating the factor so many times, we place over it, on the right, a figure denoting how often the number or magnitude has been multiplied by itself; e. g. $a^4 = aaaa = a, a, a, a$, $9^3 = 9 \times 9 \times 9 = 729$.

EXTENSION, in *philosophy;* one of the common and essential properties of body, or that by which it possesses or takes up some part of universal space.

EXTINGUISHER. The instrument commonly employed for extinguishing the light of a candle may have its value very materially increased, and indeed may be made self-acting, by a very small addition to its cost. The arrangement is shown in the accompanying engraving. It is placed on the candle and firmly fastened with a *clip*, held together by a small ring, and a wire or needle thrust into the tallow is made to support the extinguisher. As soon as the candle burns sufficiently low to permit the escape of the pin, the extinguisher falls, and, by entirely closing every passage for the admission of air, extinguishes the light.



EXTRACT (*extractum*). When chemists use this term, they generally mean the product of an aqueous decoction. In pharmacy, it includes all those preparations from vegetables which are separated by the agency of various liquids, and afterwards obtained from such solutions, in a solid state, by evaporation of the menstruum. It also includes those substances which are held in solution by the natural juices of fresh plants, as well as those to which some menstruum is added at the time of preparation. Now, such soluble matters are various, and mostly complicated, so that chemical accuracy is not to be looked for in the application of the term. Some chemists, however, have affixed this name to one particular modification of vegetable matter, which has been called *extractive*, or *extract*, or *extractive principle;* and, as this forms one constituent part of common extracts, and possesses certain characters, it will be proper to mention such of them as may influence its pharmaceutical relations. The extractive principle has a strong taste, differing in different plants: it is soluble in water, and its solution speedily runs into a state of putrefaction, by which it is destroyed. Repeated evaporations and solutions render it at last insoluble, in consequence of its combination with oxygen from the atmosphere. It is soluble in alcohol, but insoluble in ether. It unites with alumine, and, if boiled with neutral salts thereof, precipitates them. It precipitates with strong acids, and with the oxides from solutions of most metallic salts, especially the muriate of tin. It readily unites with alkalies, and forms compounds with them, which are soluble in water. No part, however, of this subject, has been hitherto sufficiently examined. In the preparation of all the extracts, the London Pharmacopœia requires that the water be evaporated, as speedily as possible, in a broad, shallow dish, by means of a water-bath, until they have acquired a consistence proper for making

pills; and, towards the end of the inspissation, that they should be constantly stirred with a wooden rod.

These general rules require minute and accurate attention, more particularly in the immediate evaporation of the solution, whether prepared by expression or decoction, in the manner, as well as the degree, of heat by which it is performed, and the promotion of it by changing the surface by constant stirring, when the liquor begins to thicken, and even by directing a strong current of air over its surface, if it can conveniently be done. It is impossible to regulate the temperature if a naked fire be used; and, to prevent the extract from burning, the use of a water-bath is, therefore, absolutely necessary.

Extractor, in *midwifery;* an instrument, or forceps, for extricating children by the head.

Extrados; the outline of an arch.

Extravasation, in contusions, and other accidents of the cranium, is when one or more of the blood-vessels distributed on the *dura mater* are broken, whereby there is such a discharge of blood as oppresses the brain, frequently bringing on violent pains, and at length death itself, unless the patient is timely relieved.

Extremities. This term is applied to the limbs, as distinguishing them from the other divisions of the animal, the head and trunk. The extremities are four in number, divided, in man, into upper and lower; in other animals, into anterior and posterior. Each extremity is divided into four parts; the upper into the shoulder, the arm, the fore-arm, and the hand; the lower into the hip, the thigh, the leg, and the foot.

Eye. Of all our coporeal senses that of vision may be considered as the most obviously essential to the acquirement of knowledge.

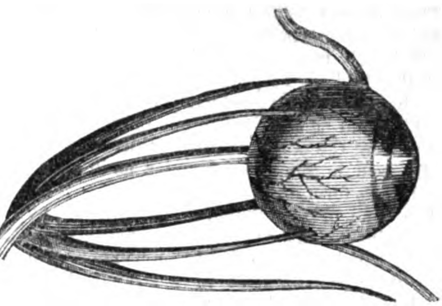
The eye, though the most wonderful, and at the first view the most complicated part of animal anatomy, is in reality nothing more than a camera-obscura; the various humours forming one powerful lens of an exceeding short focal distance on one side, while, on the other, it is allowed to embrace a very considerable space, and this is called the field of vision.

In order that we may properly understand the nature of vision, it will be necessary to furnish a brief anatomical description of the eye; which is composed of several coats or cases, one within the other, and filled with transparent humours of different degrees of density. The outer coat of the eye is called the sclerotica. It is exceedingly strong, and the muscles that move the eye are attached to it. What is called the white of the eye is a part of this coat. The cornea bulges out a little from the eyeball; it is circular, and exceedingly transparent. The next coat to the sclerotica is called the choroides, which serves as a lining to it. It is of a dark colour in the human eye, but white in cats and owls, and green in most animals that live on grass and vegetables. Its texture is soft and pulpy, and too weak to be susceptible of muscular motion, except at its extremities towards the front of the eye. Like the sclerotica, it is distinguished into two parts; the fore part being called the iris, while the hinder part retains the name of the choroides. The iris commences immediately under the commencement of the cornea. It there attaches itself more strongly to the sclerotica by a cellular substance, forming a kind of white, narrow, circular rim, called the ciliary circle. The iris is that remarkable circle which gives the eye its character as to colour; it is composed of two sets of muscular fibres; the one tending, like radii, towards the centre of the circle, and the other forming a number of concentric circles round the same centre. The central part of the iris is perforated, and the aperture, which is called the pupil, is always round, but varied in diameter by the action of the two sets of muscular fibres composing the iris. When a very luminous object is viewed, the circular fibres contract, the radial are relaxed, and thus the size of the pupil is diminished; on the other hand, when the objects are dark and obscure, the radial fibres of the iris contract, the circular are relaxed, and the pupil is enlarged, so that it admits a greater quantity of light. By candle-light, the contraction and dilation of the pupil may be very distinctly observed, with the assistance of a looking-glass. If, with our eyes directed to the mirror, we bring the candle close to our face, we shall find the pupil become very small; if the candle be removed, and completely shaded for about a minute, and then brought to its former place, it will be found that the pupil has greatly dilated, and that it again contracts as the light draws nearer: if the light shine much more strongly on one eye than the other, the pupil of the shaded eye will not contract so much as the other. The whole of the choroide membrane is opaque, by which means no light can enter the eye but what passes through the pupil: but to render the chamber of the eye still darker, the posterior surface of this membrane is covered with a dark-coloured mucus, called the pigmentum. Under the iris, there is a prolongation of the choroides, which forms a circular band of radial fibres, turning inwards towards the centre of the eye, and filled up between with a black mucus, giving it the appearance of a membrane. This circular band is called the ligamentum ciliare, or ciliary ligament. The third and *last* coat of the eye is called the retina. This is a fine and delicate membrane, being an expansion of the optic nerve, which proceeds from the brain. It is spread, like a net of exquisite delicacy, all over the concave surface of the choroides, and terminates at the ciliary ligament. It receives the images of objects, which are depicted upon it by the rays of light that enter at the pupil. It is of itself transparent, and of an ash-coloured white, but appears black on account of the dark-coloured pigmentum behind it. The optic nerve, which passes through a small hole in the bony cavity containing the eye, and conveys to the sensorium the impressions made on the retina, is not in the centre of the eye, but a little on one side, inclining towards the nose.

The tunica choroides is described by some authors as consisting of two laminæ. This description, however applies much more accurately to the eyes of some animals, particularly to those of sheep, than to those of man. Those who suppose the choroides to consist of two laminæ, describe the external one as terminating at the ciliary ligament, and the internal one as extending farther, to form the iris. The iris is described as consisting of two laminæ, and it is very certain that two sets of fibres may be observed. These are supposed to be muscular, and from the mobility of the iris, there seems no reason to doubt of their being really so. Some of the fibres are orbiculor, and lie round the pupil; others are straight, and extend from the circumference of the iris to its centre. We have seen that the iris has motions of such a

nature, that the pupil is contracted on the approach of a strong light and is dilated in proportion as the light is less vivid. By this admirable yet simple contrivance, the eye adapts itself to the different proportions of light to which it is exposed. If the iris was always as much contracted as it is when exposed to the light of noon-day, a weaker light, such as that of the moon, could not be admitted in sufficient quantity to answer any useful purpose. On the contrary, if the pupil was immovably dilated, we might take advantage of the scattered rays of light, but should be distressed and blinded by the bright effulgence of the mid-day sun. When a strong light succeeds to darkness, we are under the necessity of closing the eyelids, or of turning away the head, till the pupil has been accommodated to the change by the contractile powers of the iris. Cats, and some other animals which prey after night-fall, have the greatest power of changing the size of the pupil, though it is an erroneous opinion to suppose that they can see in the dark. Nearly the whole of the curtain of the eye can be drawn back to accommodate itself to a very dilule ray, but without light they cannot see.

The three transparent substances inclosed by the coats of the eye, are called the aqueous, crystalline, and vitreous humours. They are shown in the section *Plate* Ear and Eye, *fig*. 4. The first of these, or *aqueous* humour, resembles water, whence its name. It gives a protuberant figure to the cornea, filling the two cavities between the cornea and ciliary ligament, which cavities communicate by the pupil. The refractive power of the aqueous humour is similar to that of water.—The second, or *crystalline* humour, is, like the former, transparent, in which it exceeds that of the purest crystal; it has the consistence of a hard jelly, growing somewhat softer from the middle towards the edges. Its form is that of a double convex lens, but more convex on the interior than the exterior surface.—Resembling a lens in its form, it also resembles one in its use: it converges the rays which pass through it from every visible object to its focus on the retina. It is inclosed in a fine transparent cover, or membrane, which is attached to the ligamentum ciliare, and by that means it is suspended. The radial fibres of the ligamentum ciliare have the power of contracting and dilating occasionally, by which means they alter the shape or convexity of this natural lens, and shift it a little backward or forward in the eye, so as to adapt its focal distance from the retina to the different distances of objects. Without this, or some equivalent arrangement, we should only see those objects distinctly that were at one distance from the eye.—At the back of the crystalline lies the third, or vitreous humour. The *vitreous* humour was so called from a supposed resemblance to melted glass; it is a clear and gelatinous fluid, very much resembling the white of an egg. It fills about three-fourths of the globe of the eye, and extends from the posterior part of the eye as far as the ciliary ligament. It is contained in a fine transparent capsule, or membrane, and when carefully removed from the globe of the eye, preserves its consistence for some time, being supported by its capsule, but afterwards runs off, and the capsule diminishes in size. The thin capsule which surrounds the vitreous humour sends off a number of membranous processes into the vitreous substance, where they form cells, which communicate with each other, and afford a high degree of firmness and tenacity to the whole mass. The eye, with its muscles, and nerve is shown beneath.



Dr. Brewster has very accurately ascertained the amount of refraction in the various coats and humours of the human eye, as well as the relative measures of those bodies; and as the results differ from those of Dr. Wollaston and others, who had previously examined the subject, they may be considered of considerable importance in the anatomy as well as the optical properties of that organ. Taking the refractive power of water at 1.3358, the following table will convey the result of Dr. Brewster's experiments.

Refractive power of the	aqueous humour	1.3366
	vitreous humour	1.3394
	outer coat of crystalline	1.3767
	middle coat of ditto	1.3786
	central part of ditto	1.3990
	whole crystalline	1.3839

		Inch.
Diameter of the	crystalline	0.378
	cornea	0.400
Thickness of the	crystalline	0.172
	cornea	0.042

The direct action of light on the retina may easily be illustrated. If we suppose a pencil of rays radiating from a luminous surface, those which impinge on the opaque sclerotica are reflected, and have no concern in the production of vision, while those which by falling very obliquely, form a very considerable angle with the cornea, are also reflected without penetrating into the aqueous humour. The rays, which fall within an angle of about 48 degrees, pass through this membrane, undergoing a certain refraction, by which they are brought nearer to the line of the axis of the cornea; and, if produced, would converge into a focal point beyond the bottom of the eye. From the cornea, the rays pass into the aqueous humour.—They are there divided by the dispersive powers of this fluid, so that, if continued in the same medium, they would not only converge beyond the back of the eye, but, on account of the aberration caused by their different refrangibility, would produce a confused and coloured image.

The rays collected by the cornea pass through the pupil. Those which come in an unfavourable direction are either reflected by the iris, or absorbed by the pigmentum on its posterior surface. The pupil admits only those rays which are nearest to the axis of vision. They then meet with the crystalline, which, by its refractive power, collects them, and brings them into foci, after passing through the less refrac-

tive medium of the vitreous humour on the concave surface of the retina. See *Plate* EAR and EYE, *fig*. 5.

They do not impart a correct perception of the body which reflects them, unless they fall on the retina precisely in the order in which they are detached from that body. To produce this effect, it is necessary that all the rays which proceed from any one point, should be collected in one point of the retina; and that all the points of union thus formed, should be disposed in the same manner as in the body, of which they form an image.

The cone of rays which proceeds from any luminous point to the cornea forms another cone, the apex of which falls on the retina. These two cones have their axes almost in a straight line. That which is perpendicular to the middle of the crystalline proceeds directly to the bottom of the eye; that which comes from above falls inferiorly; that on the left proceeds to the right, and so on with respect to the others; thus an inverted image is formed on the retina.

There are five natural methods by which we judge of the distance of objects from the eye. First, by the angle which is made by the optic axes; for want of this direction, it has been observed, that persons who are blind of one eye, frequently make a slight mistake as to the situation of objects. Secondly, by the apparent magnitude of the objects. By depending upon this method, we are frequently deceived in our estimates of distance by any extraordinary large objects; as in approaching a large city, or edifice, we fancy them nearer than they really are. This furnishes us with a reason why animals and other small objects seen contiguous to large mountains appear exceedingly small; for we imagine the mountain to be nearer to us than it actually is. When we look down also from a high building, the objects beneath us appear much smaller than they would at the same distance on the level ground; the reason is, plainly, because we have no distinct idea of distance in that direction, and therefore judge by the impressions upon the retina, whereas custom has corrected our judgment in the other case. The third method of determining the distance of objects is by the force and vividness of the colours; and the fourth is analogous to it; namely, by the different appearance of the minute parts. When these appear distinct, we judge the object to be near; and the contrary, when they appear faint and confused. Fifthly, we are assisted in judging of the distance of any particular object by the other objects which are interposed. On this account distances upon uneven ground do not appear so great as upon plain; for the valleys, rivers, and other objects that lie low, are many of them lost to the sight. This, too, is the reason why the banks of a river appear contiguous when the river lies low and is not seen.

Though every object that is before our eyes has its image in both organs, yet objects are not seen double; because, having previously ascertained, by help of the touch, that such an object was single, at the same time that each optic axis was directed towards it, and its image was painted in the corresponding parts of each retina, we have connected the idea of unity with the sentiment of those impressions, and have accustomed ourselves to identify two sensations, which, so to speak, are in unison with one another. But if the two optic axes no longer concur towards the same point, as when we slightly press one eye sideways with the hand, the object appears double, and it is evident that the two images do not then fall on the corresponding parts of the retina.

It has often been a subject of inquiry, why we see objects in their true position, though the image on the retina is inverted, but no satisfactory solution of the difficulty has ever been given. And we should be as little likely to receive an answer, if we were to ask, why we do not preceive every object bent, because the image of it is depicted upon a concave surface. It is certain, that unless distinct images are painted on the retina, objects cannot be clearly perceived. If, from too little light, remoteness, or any other cause, a picture is indistinctly painted on the retina, an obscure or indistinct idea of the object is conveyed to the mind. The picture on the retina is, therefore, so far the cause of vision, that our ideas of visible objects vary as it varies, and when it is not formed, nothing is seen. Yet we may fairly conclude that the mind does not look upon the image on the retina; for in cases of the gutta serena, a disorder which affects only the optic nerve, the pictures on the retina are as perfectly formed as in the best eyes, although the patient is afflicted with incurable blindness. It is the optic nerve, therefore, which conveys the impressions made on the retina to the brain; but how they are communicated to the mind, is screened from the view of man. It has been supposed that we acquire by experience the habit of seeing objects erect; but there are many striking facts to prove the contrary: persons who have been blind from infancy, and who have been suddenly restored to sight by a surgical operation, have not been led into the smallest mistake. In fact, no reason can be given why the mind should not perceive as accurately the position of bodies, when the rays reflected from the upper part of those bodies fall upon the lower parts of the eye, as if the contrary took place.

The impressions of light on the retina appear to be always in a certain degree permanent, and the more so as the light is stronger; but it is uncertain whether the retina possesses this property merely as a phosphorescent body, or in consequence of its peculiar organization. The duration of the impression is usually limited to less than half a second: hence, a luminous object revolving in a circle, makes a lucid ring: and a shooting star leaves a train of light behind it, which is not always real. If the object is painfully bright, it generally produces a permanent spot, which continues to pass through various changes of colour for some time, and then gradually vanishes. Dr. Roget, in an ingenious paper published in the Transactions of the Royal Society, has farther illustrated this subject by reference to the revolution of a wheel made to revolve behind a series of perpendicular bars, which change in appearance from radical spokes to curved lines. This effect may, however, be better illustrated by reference to *fig*. 6, *Plate* EAR and EYE.

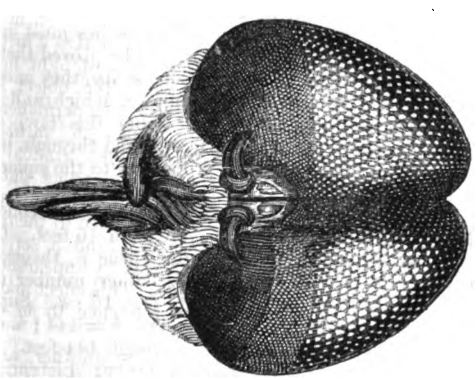
It may now be advisable to examine another, and no less important part of the anatomy of this organ, or the arrangement made for its protection from any inconvenience that may arise from the attacks of insects, or the particles of dust which are continually floating in the air. This is effected by the *eyelids*, which, like two substantial curtains, protect and cover the eyes when we are asleep; and, while waking, they diffuse, by their motion, and by peculiar secret-

ing organs, a fluid over the eye, which cleans and polishes it.

The *eyebrows* also defend the eye from the rays of light which might otherwise prove too strong for the optic nerve; and that the *eyelid* may shut with greater exactness, each edge is stiffened by a cartilaginous arch, from which proceed the eyelashes, thus serving to warn the eye of dangers, while it protects it from the straggling mote.

The more we investigate the works of nature, the greater reason have we to admire the wisdom of its Author; and that wonderful adaptation of our organs, in the minutest particulars, to the general laws which pervade the universe. The mechansim of the eye affords a striking illustration of this remark. We have hitherto supposed the eye to be a lens possessing the power only of enlarging and contracting its dimensions; and from the previous description given of the rays of light, it may be considered as incapable of obviating the confusion which must arise from their different degrees of refrangibility. But here the use of that wonderful structure of parts, and the different fluids in the eye, is clearly seen. The eye is, in fact, a compound lens; each fluid has its proper refrangible power. The shape of the lenses is altered at will, according to the distance of the object; and the three substances having the proper powers of refrangibility, the effects of an achromatic glass are without difficulty produced by the eye.

The eyes of fish differ very much in form from those we have been now describing. The crystalline lens is round, instead of being flattened, as in the human eye. This arrangement is necessary from the circumstance that they view all objects through a much denser medium, and as such they require a greater magnifying power. But one of the most extraordinary exceptions to the ordinary laws of nature in this respect, will be found in the common house fly, of which an example is given beneath. Hundreds of eyes, or distinct organs for the purposes of vision, are here congregated together, and the little insect is thus enabled to see distinctly any approaching danger, without moving its body.



FAÇADE is the outside or external aspect of an edifice. As in most edifices only one side is conspicuous, viz., that which faces the street, and usually contains the principal entrance, this has been denominated, *par eminence* the *façade*. As a work of architecture, it must form a whole, of which all the parts are properly related and symmetrically arranged, and correspondent to the character or style of the edifice.

FACE; the front part of the head, the seat of most of the senses, is composed of the forehead, the eyelids and eyebrows, the eyes, the nose, the cheeks, the mouth, the lips, the jaws, the teeth. Beneath the skin, which, in the face, is more delicate, more soft, more sensitive and clear than in other parts, are numerous muscles, by which the motions of the skin are produced. They are enveloped in fat. There are, also, a greater number of vessels and nerves in the face than in any other external part. Underneath these is the bony basis, which, exclusive of the teeth, is composed of 14 bones, called, in anatomy, the *bones of the face*. The anterior part of the skull (*os frontis*) also forms an important feature of the face. Of all these bones, the lower jaw, only, is movable, being articulated with the basis of the skull. The other bones are firmly joined together, and incapable of motion. The character of each individual is strongly marked by the conformation of the countenance. (See PHYSIOGNOMY.) The face also acquires its expression from bodily habits and actions, and particularly from diseases. The form of the bones produces a great difference in the external appearance of the face, in brutes and in men. The jaws of the former are more projecting, so as to form an acute angle with the forehead; those of the latter recede in proportion to the prevalence of the human formation and beauty. On this relation of the jaw to the forehead is founded the facial line described under CRANIUM.

FACIAL ARTERY, in *anatomy*, is synonymous with the external maxillary.

FACING, in *ship carpentry*, is letting one piece of timber into another with a rabbet.

FAC SIMILE; an imitation of an original in all its traits and peculiarities; a copy as accurate as possible. Thus fac similes of old manuscripts, or of the handwriting of famous men, or of interesting documents, are made in engraving or lithographic prints. The object of fac similies is various; in the case of old manuscripts, they are intended to show the age of the MS. by the nature of the characters.

FACTOR, in *arithmetic*, is any number which is multiplied by another: thus 7 and 4 are the factors of 28. They are divided into simple and composite. A simple factor is one which is divisible only by itself.

In commerce a *factor* is an agent, employed by merchants residing in other places, to buy and sell, and to negociate bills of exchange, or to transact other business on their account. Establishments for trade, in foreign parts of the world, are called *factories*.

FADEN; a German measure corresponding to the *fathom*, equal to a *klafter*, or six feet.

FAÏENCE, imitation porcelain; a kind of fine pottery, superior to the common pottery in its glazing, beauty of form, and richness of painting. It derived its name from the town of Faënza, in Romagna, where it is said to have been invented in 1299. A fine sort of pottery was manufactured there at that period, which the Italians called *Maiolica*, probably from its inventor. Some pieces were painted by the great artists of the period, Raphael, Giulio Romano, Titian, and others, which are highly valued, as monuments of early art. The *Maiolica* reached its highest perfection between 1530 and 1560. The King of Würtemberg possesses a rich collection of it.

The modern Faïence appears to have been invented, about the middle of the 16th century, at Faënza, and obtained its name in France, where a man from Faënza, having discovered a similar kind of clay at at Nevers, had introduced the manufacture of it. Towards the end of the 17th century, the city of Delft, in Holland, became famous for the manufacture of Faïence, which was called also *Delft-ware*. It does not, however, resist fire well. Our own stone ware, made of powdered flint, has some external resemblance to the Faïence, but is, in reality, entirely different.

Fair, in *commerce;* a greater kind of market granted to a town, by privilege, for the more speedy and commodious buying and selling, or providing such things as the place stands in need of. These fairs are usually held twice a year; in some places only once a year; and, by statute, they shall not be held longer than they ought by the lords thereof, on pain of their being seized into the king's hands, &c. Also proclamation is to be made, how long they are to continue; and no person shall sell any goods after the fair is ended, on forfeiture of double the value, one fourth to the prosecutor, and the rest to the king. There is a toll usually paid at fairs, for the privilege of erecting stalls, from which to sell goods, as well as booths, either for entertainment or pastime.

The most important fairs now held are, probably, those of Germany, and particularly the Leipsic fairs. In German, a fair is called *Messe*, which also signifies a mass. High masses, on particular festivals, collected great numbers of people, and thus, probably, became the origin of markets, and, at a later period, of fairs, which, as we have already said, are only privileged markets. The three chief fairs of Germany are those of Leipsic, Frankfort on the Maine, and Brunswick. The Leipsic book-fair is unique. The Leipsic fair, beginning January 1, is called *New-year's fair:* the Easter fair, or Jubilee fair, begins on Jubilee Sunday, and Saint Michael's fair, on the Sunday after September 29. Each lasts three weeks, but only the two last are important. The Easter fair is the most important. Frankfort on the Maine has the Easter fair and Autumn fair, and Brunswick, the Candlemas fair and St. Lawrence's fair. Important fairs are also held at Alessandria and Sinigaglia in Italy, at Lyons and Beaucaire in France, Bolzano in the Tyrol, Zurzach in Switzerland, Niznei-Novgorod in Russia, Warsaw in Poland, &c. But fairs cannot now have the importance which they formerly had, because the communication between different parts of a country has become so easy that merchandise is much oftener ordered directly than formerly.

Fairy Circle, or Ring; a phenomenon frequent in the fields, &c., supposed by the vulgar in England to be traced by the fairies in their dances. There are two kinds: one of about seven yards in diameter, containing a round, bare path, a foot broad, with green grass in the middle of it. The other is smaller in size, encompassed with a circumference of grass, greener and fresher than that of the middle. Some attribute them to lightning, and others to a kind of fungus which breaks and pulverizes the soil.

Fake; one of the circles or windings of a cable or hawser, as it lies disposed in a coil. The fakes are greater or smaller, in proportion to the extent or space which a cable is allowed to occupy where it lies.

Fall of Bodies. All bodies on the earth, by virtue of the attraction of gravitation, tend to the centre of the earth. If this tendency acts freely, the body falls towards the earth; if it is opposed by some obstruction, pressure ensues; if the tendency is partly checked and partly efficient, pressure and descent both ensue. A ball, held in the hand, presses downward; if dropped, it descends perpendicularly; if placed on an inclined plane, it rolls down; in doing which it presses the plane with part of its weight. The laws, according to which this motion takes place, were formerly the subject of the most erroneous theories.

According to the physics of Aristotle, the velocity of the fall of bodies is in proportion to their weight. Consequently any body should fall with ten times more velocity than another, which is only one tenth part as heavy. This error Galileo attacked, while a student in Pisa. Soon after his appointment to a professorship, he declared himself against this and other maxims of the Peripatetic philosophy. He ascended the cupola of the lofty tower at that place, and dropped bodies of very unequal weight, which, if their specific gravity did not differ too much, were found to reach the ground at nearly the same time. Galileo eventually proved, when professor in Padua, the correctness of his position, by means of two pendulums, of equal length, and very unequal weight, which, nevertheless, performed their vibrations with equal velocity. Equally erroneous hypotheses have been grounded on the fact, that the velocity of the descent increases in proportion to the space passed through. The Aristotelians said, that all bodies had a natural tendency to the centre of the earth, and hastened towards it with more velocity the nearer they approached it. Others explained the accelerated rapidity of the descent by the augmented pressure of the atmosphere; and the general opinion was that the velocity increased in the same proportion as the space passed through, and, consequently, that a body, after falling five fathoms, would have five times the velocity it had after falling through one fathom—an opinion, which, notwithstanding its great simplicity and plausibility, involves an absolute impossibility. Galileo, at length, arrived at the true opinion, that the velocity of falling bodies must increase in proportion to the time; and he proved that, as bodies can never be destitute of gravity, they must every instant receive a new impulse, which unites with the effect of the former. From this law, it moreover follows, that the spaces passed through, by bodies falling freely, are in proportion to the square of the times.

Experiments have shown that, in the first second, the fall amounts to a little more than 16 feet. In order to ascertain, therefore, the space h, through which a body would fall in any other number of seconds t, we have the equation $1 : t^2 :: 16 : h$. Supposing, for example, $t = 3$, we have $h = 144$; i. e. in three seconds, the body falls through 144 feet.

Fallopian Tubes, in *anatomy*, are two ducts arising in the womb, one on each side of the fundus, and thence extended to the ovaries. These are called *tubes*, from their resemblance to a trumpet, and *Fallopian* from Gabriel Fallopius, a physician of Italy, in the 16th century, who is reported to have first ascertained their use and office.

Fallow Land is ground that has been left untilled for a time in order that it may recover itself from

an exhausted state; but to render a barren soil fertile, it ought to be frequently turned up to the air, and to have mixed with it manures of animal dungs, decayed vegetables, lime, marl, sweepings of streets, &c. In turning over the soil, the chief implements of the gardener are the spade, the hoe, and the mattock; and those of the farmer are the plough, the harrow, the roller, the scythe, and the sickle. As a succession of the same crops tends to impoverish the soil, a rotation of different crops is necessary. Potatoes, grain, and white crops are exhausting; but, after them, the soil is ameliorated by tares, turnips, and green or plant crops.

False, in *music;* an epithet applied by theorists to certain chords, called *false*, because they do not contain all the intervals appertaining to those chords in their perfect state: as a fifth, consisting of only six semitonic degrees, is denominated a *false* fifth. Those intonations of the voice which do not truly express the intended intervals are also called *false*, as well as all ill-adjusted combinations; and those strings, pipes, and other sonorous bodies which, from the ill disposition of their parts, cannot be accurately tuned. Certain *closes* are likewise termed *false*, in contradistinction to the full or final close.

Falsetto; that species of voice in a man, the compass of which lies above his natural voice, and is produced by artificial constraint.

Fanfare; a short, lively, loud, and warlike piece of music, composed for trumpets and kettle-drums. Also small, lively pieces, performed on hunting horns, in the chase. From its first meaning is derived *fanfaron*, a boaster, and *fanfaronade*, boasting.

Fantasia; the name generally given to a species of composition supposed to be struck off in the heat of imagination and in which the composer is allowed to give free range to his ideas, and to disregard those restrictions by which other productions are confined. Some writers limit the application of this term to certain extemporaneous flights of fancy; and say, that the moment they are written, or repeated, they cease to be *fantasias*. This, they add, forms the only distinction between the *fantasia* and the *capricio*. The *capricio*, though wild, is the result of premeditation, committed to paper, and becomes permanent; but the *fantasia* is an impromptu, transitive and evanescent, exists but while it is executing, and, when finished, is no more.

Farina; the most important part of vegetable food. A patent has lately been obtained for procuring nutritious food of this description, which is exceedingly economical.

The patentee proposes to prepare from carrots, turnips, beetroot, mangelwurzle, or potatoes, or any other roots of that kind which may be conveniently obtained, a fine white and nutritious farinaceous substance, capable of being converted to the best white bread, and to all the purposes of fine wheaten flour; and also into sugar.

The roots are to be washed perfectly clean, or deprived of their skins, and are to be cut into thin slices, and then submitted to the action of a solution of acid in water; sulphuric acid is to be preferred, but any of the other acids will answer the purpose. The quantity of acid to be employed will depend upon the roots to be acted upon: from two to ten pounds of acid will be required for every hundred weight of roots; carrots will require the smallest quantity of acid, potatoes the greatest.

This steeping of the roots in the solution of acid, will perfectly change their characters and taste, and when they are sufficiently acted upon, the acid and other matters held in solution, are to be removed from the slices of the roots, by washing them repeatedly with pure water. They may be afterwards dried by exposure to the air and sun, or by a kiln at a low temperature; and when the mixture has been evaporated, and the slices of the roots brought to perfect dryness, they may be submitted to the operation of a mill, and ground into farina or white flour in the ordinary way.

The slices of roots thus prepared will retain their nutritious properties unimpaired for any length of time, and in any climate, if not exposed to damp; and the flour obtained from grinding them will have exactly the same properties, appearance, and flavour, as wheaten flour.

In preparing sugar from the said roots, they are to be washed and sliced, and submitted to the action of the acid in the way above described, and then reduced into farina, as a first part of the process. The farina is then to be boiled with a solution of acid, in the proportion of about two pounds of the acid to one hundred weight of the farina. A saccharine matter is produced by this operation, which may be crystallized or granulated into sugar, by the ordinary mode of evaporating cane juice, or other vegetable extracts from which sugar is commonly made.

Instead of reducing the roots to a farinaceous powder, as last described, for the production of sugar, they may be steeped in their raw state in a solution of acid, in the proportion of ten pounds of acid to every hundred weight of roots; and after having been acted upon by the acid for about three days, the saccharine matter will be produced, which may be treated as before described, and sugar obtained therefrom.

Farthing; the fourth part of a penny; originally the *fourth thing*, or the fourth in the integer one penny.

Fascets, in *glass making;* the irons thrust into the mouths of the bottles when employed to remove them into the annealing oven.

Fascines; bundles of boughs, twigs, &c., sixteen feet in length, and usually one foot in diameter. They are made on trestles, or any kind of support placed about two feet asunder. The twigs are placed on this machine, drawn tightly together by a cord; the bands are then passed round them at the distance of two feet from each other. The twigs which exceed a given length are cut off or bent back, and the ends are bound into the bundle. Fascines are used in sieges, hydraulic constructions, &c. Very long, thin ones are used in constructing batteries, whence they are called *saucissons*, or *battery-sausages*.

Fashion Pieces; the aftmost or hindmost timbers of a ship, which terminate the breadth, and form the shape of the stern. They are united to the stern post, and to the extremity of the wing transom by a rabbet, and a number of strong nails or spikes driven from without.

Fat of Animals. Animal oils and fats, as they differ only in the fluidity of the former at common temperatures, while the latter are generally concrete, will be treated of together in the present article. Of animal oils, whale oil and sperm oil are most generally known in this country; and among the princi-

pal varieties of fat are, spermaceti, butter, tallow, lard, and suet. Whale oil, or train oil, is extracted from the blubber of the whale (principally the *balæna mysticetus*). Originally it is a firm, solid fat. To obtain the oil, the blubber is melted in large copper vessels. A large quantity of water separates, and on the surface there floats a solid matter, called *fenks*, which is probably coagulated albumen. The more moderate the heat, and the shorter its duration, the paler and better is the oil; but this is attended with a diminution in its quantity. The deep colour is owing partly to too great heat in the boiling, and partly to blood and other impurities, which are unavoidably mixed with it. What is carefully extracted in Greenland is perfectly pale and limpid, and free from smell, and burns with a pure and bright flame.

Whale oil requires to be kept in close vessels, to prevent the action of the air. It is rendered more fluid and combustible by adding to it a little cold-drawn linseed oil; but it cannot, by any treatment, be made so fit for burning in lamps as spermaceti oil. The best way of using it is found to be by converting it into gas. It may be deprived of its offensive odour, however, by the use of chloride of lime. Its specific gravity is 0.9191. It boils at 640° Fahr., and may be distilled; but its properties are then materially altered, or, rather, it becomes a new substance, its specific gravity being diminished to 0.868, its boiling point lowered, and its inflammability much increased. Whale oil consists of carbon 68.87, oxygen 16.10, and hydrogen 15.03.

Sperm oil, or spermaceti oil, forms part of the oily substance found in the cranium of the spermaceti whale, or *physeter macrocephalus*. The oil is separated by putting the mass into a woollen bag and pressing it, by which the fluid is made to run out, and the solid residue, when washed with a weak alkaline ley, affords spermaceti. This kind of oil is much purer than train oil, and burns away without leaving any charcoal on the wicks of lamps. In composition it differs but slightly from whale oil, consisting, according to Doctor Ure, of carbon 78, oxygen 10.20, and hydrogen 11.80. The fat of animals, or more solid animal oils, may be separated from the membranous and other substances with which it is united by melting it at a gentle heat, with the addition of a small quantity of water. Fat thus prepared is called *lard*, when of a soft consistence, and *tallow* when harder. It is insipid, and sometimes free from smell; at others, it has a distinct and peculiar odour. It is apt to become rancid, however, by keeping—a change connected with the absorption of oxygen. It is insoluble in water or in alcohol. It melts at 90° or 100° Fahr.; by raising the heat it is rendered more acrid, and exhales a pungent vapour. In close vessels it is decomposed, and, among other products, yields a large quantity of olefiant gas. It is inflammable, and affords, by combustion, water and carbonic acid.

The acids act chemically on fat. Sulphuric acid chars it. Nitric acid, mixed with it in a small quantity, gives it a firmer consistence, and renders it soluble in alcohol. In this state it has been called *oxygenated* fat. The animal oils and fats combine with the alkalies, and form with these perfect soaps. With some of the earths, and metallic oxides also, they form saponaceous compounds. They even facilitate the oxidation of some of the metals, as copper and mercury, by the atmospheric air. Animal fat is not homogenous, but consists of two different proximate principles, called *stearine* and *elaine*; the former of a firm consistence, resembling suet or tallow, the other more soft or liquid, and analogous to vegetable oils. (For an account of the mode of separating these principles, and their properties when separate, see STEARINE; and for a view of the theory of saponification, see SOAP.)

FATA MORGANA: a singular aërial phenomenon seen in the straits of Messina. When the rising sun shines from that point whence its incident ray forms an angle of about 45° on the sea of Reggio, and the bright surface of the water in the bay is not disturbed either by the wind or current, when the tide is at its height, and the waters are pressed up by currents to a great elevation in the middle of the channel, the spectator being placed on an eminence, with his back to the sun and his face to the sea, the mountains of Messina rising like a wall behind it, and forming the back ground of the picture—on a sudden there appear in the water, as in a catoptric theatre, various multiplied objects—numberless series of pilasters, arches, castles, well-delineated, regular columns, lofty towers, superb palaces, with balcônies and windows, extended alleys of trees, delightful plains, with herds and flocks, armies of men on foot, on horseback, and many other things in their natural colours and proper actions, passing rapidly in succession along the surface of the sea, during the whole of the short period of time while the above-mentioned causes remain.

All these objects, which are exhibited in the Fata Morgana, are proved by the accurate observations of the coast and town of Reggio, by P. Minasi, to be derived from objects on shore. If, in addition to the circumstances we before described, the atmosphere be highly impregnated with vapour, and dense exhalations, not previously dispersed by the action of the wind and waves, or rarified by the sun, it then happens, that, in this vapour, as in a curtain extended along the channel to the height of above forty palms, and nearly down to the sea, the observer will behold the scene of the same objects not only reflected from the surface of the sea, but likewise in the air, though not so distinctly or well defined as the former objects from the sea. Lastly, if the air be slightly hazy and opaque, and at the same time dewy, and adapted to form the iris, then the above-mentioned objects will appear only at the surface of the sea, as in the first case; but all vividly coloured or fringed with red, green, blue, and other prismatic colours. As the day advances, the fairy scene gradually disappears.

A very singular instance of atmospherical refraction is described in the *Philosophical Transactions*, as having taken place at Hastings. The coast of Picardy, which is between 40 and 50 miles distance from that of Sussex, appeared suddenly close to the English shore. The sailors and fishermen crowded down to the beach, scarcely believing their own eyes; but at length they began to recognise several of the French cliffs, and pointed out places they had been accustomed to visit. From the summit of the eastern cliff or hill, a most beautiful scene presented itself: at one glance the spectators could see Dungeness, Dover cliffs, and the French coast, all along from Calais to St. Vallery; and, as some affirmed, as far to the westward even as Dieppe. By the telescope, the French fishing-boats were plainly seen at anchor, and the different colours of the land on the heights

with the buildings, were perfectly discernible. This refractive power of the atmosphere was probably produced by a diminution of the density of its lower stratum, in consequence of the increase of heat communicted to it by the rays of the sun, powerfully reflected from the surface of the earth. (See MIRAGE.) Similar appearances occur also in the great sandy plains of Persia, of Asiatic Tartary, in Lower Egypt, on the plains of Mexico, in North America, &c.

FATHOM; a measure of six feet, used to regulate the length of the cables, rigging, &c., and to divide the lead (or sounding) lines, &c.

FAUX JOUR, or *false light*; an expression in the fine arts. If a picture is placed so that the light falls upon it from a different side from that from which the painter intended to represent the light in the picture as falling upon objects, or if the picture is placed so that it is covered with a bright glare, and nothing can be distinguished, the picture is said to be in *faux jour*.

FEEDER, in *canal-building*. In order that water may not be wanting in any part of a canal, built on different levels, a supply is insured at the highest level, and thus gradually passes off, through the locks, to the lowest. The streams, which furnish the water at this and other points, are called *feeders*.

FEELING; one of the five external senses, by which we obtain the ideas of solid, hard, soft, rough, hot, cold, wet, dry, and other tangible qualities. It is the most universal of all the senses. We see and hear with small portions of our bodies, but we feel with all. Nature has bestowed that general sensation wherever there are nerves, and they are every where, where there is life. Were it otherwise, the parts divested of it might be destroyed without our knowledge. It seems that, upon this account, nature has provided that this sensation should not require a particular organization. The structure of the nervous *papillæ* is not absolutely necessary to it. The lips of a fresh wound, the *periosteum*, and the tendons, when uncovered, are extremely sensible without them. These nervous extremities serve only to the perfection of feeling, and to diversify sensation.

Like every other sense, feeling is capable of the greatest improvement: thus we see that persons born without arms acquire the nicest feeling in their toes; and, in blind people, this sense becomes so much developed, that individuals born blind, and acquiring the faculty of sight in after-life, for a long time depend rather on their feeling than on their sight, because they receive clearer ideas through the former sense. A person in this condition, who could not remember the difference of things, if he only saw them, as soon as he touched them, distinguished them perfectly well. Feeling is the most common of all the senses, as it exists in all creatures, which have any sense at all: even some plants show a sensibility to touch. Many animals have no sense but that of feeling.

FELDSPAR. (See NATURAL HISTORY.)

FELLOE; the circular wooden rim, which, with the addition of a knave and spokes, makes the wheel of a carriage.

FELLOWSHIP; the name of a rule in arithmetic, useful in balancing accounts between traders, merchants, &c.; as also in the division of common land, prize-money, and other cases of a similar kind. Fellowship is of two kinds, single and double; or fellowship without time, and fellowship with time.

Single Fellowship is when all the moneys have been employed for the same time; and therefore the shares are directly as the stock of each partner. The rule in this case is as follows:—As the whole stock : the whole gain or loss : : each man's particular stock : his particular share of the gain or loss.—*Example*. A bankrupt is indebted to A 1000*l*. to B 2000*l*. to C 3000*l*.; whereas his whole effects sold but for 1200*l*.: required each man's share. Here the whole debt is 6000*l*.; therefore

$$\text{As } 6000 : 1200 : : \begin{cases} 1000 : 200l. \text{ A's share.} \\ 2000 : 400l. \text{ B's share.} \\ 3000 : 600l. \text{ C's share.} \end{cases}$$

Double Fellowship is when equal or different stocks are employed for different periods of time. The rule in this case is as follows:—Multiply each person's stock by the time it is engaged; then say, As the sum of the products : the whole gain or loss : : each particular product : the corresponding share of the gain or loss.—*Example*. A had in trade 50*l*. for 4 months, and B 60*l*. for 5 months, with which they gained 24*l*.: required each person's particular share.

$50 \times 4 = 200$
$60 \times 5 = 300$

$$500 : 24 : : \begin{cases} 200 : 9l.\ 12s. \text{ A's gain.} \\ 300 : 14l.\ 8s. \text{ B's gain.} \end{cases}$$

FELLING OF TIMBER, in *rural economy*. In the performance of this operation, attention should in the first place be paid to the season of the year, especially where the timber is of the oak kind or such as is to be peeled for the bark, as it will only peel, or what the workmen term *run*, at a particular period, which is generally in the spring months, just before the leaves expand. With many other sorts of timber trees, this is not, however, necessary to be regarded; but they should, in general, be cut down previously to the leaves appearing.

In the work of felling there is considerable art to make them fall in the best way, which is only known by those woodmen who have had much experience. Where a large fall is therefore to be made, it is of much advantage to have men of this kind to undertake the business. The price of felling is regulated by a variety of different circumstances, as the kind of wood, the size of the trees, the nature of the situation, &c; but the work is often done by the tree, or at a fixed price for a certain number of trees.

FELTING. The texture of modern hats, which are made of fur and wool, depends upon the process of felting, which is similar to that of fulling. The fibres of these substances are rough in one direction only, as may be perceived by passing a hair through the fingers in opposite directions. This roughness allows the fibres to glide among each other, so that when the mass is agitated, the anterior extremities slide forward in advance of the body, or posterior half of the hair, and serve to entangle and contract the whole mass together. The materials commonly used for hat-making, are the furs of the beaver, seal, rabbit, and other animals, and the wool of sheep. The furs of most animals are mixed with a longer kind of thin hair, which is obliged first to be pulled out, after which the fur is cut off with a knife.

The materials to be felted are intimately mixed together by the operation of bowing, which depends on the vibrations of an elastic string; the rapid alternations of its motion being peculiarly well adapted to remove all irregular knots and adhesions

among the fibres, and to dispose them in a very light and uniform arrangement. This texture, when pressed under cloths and leather, readily unites into a mass of some firmness. This mass is dipped into a liquor containing a little sulphuric acid; and, when intended to form a hat, it is first moulded into a large conical figure, and this is afterwards reduced in its dimensions by working it for several hours with the hands. It is then formed into a flat surface, with several concentric folds, which are still farther compacted in order to make the brim and the circular part of the crown, and forced on a block, which serves as a mould for the cylindrical part.

The nap, or outer portion of the fur, is raised with a fine wire brush, and the hat is subsequently dyed, and stiffened on the inside with glue. An attempt has been made, and at one time excited considerable expectation in England, to form woollen cloths by the process of felting, without spinning or weaving. Perfect imitations of various cloths were produced, but they were found deficient in the firmness and durability which belongs to woven fabrics.

Cloth has lately been made from the sweepings of the cotton factories by felting.

FELUCCA; a little vessel with oars, common in the Mediterranean.

FEMORALIS ARTERIA, in *anatomy;* a continuation of the external iliac along the thigh.

FEMUR, in *anatomy;* the thigh, or thigh-bone, a long cylindrical bone situated between the *pelvis* and *tibia.*

FENESTRA, in *anatomy;* a name given to two small holes which appear in the cavity of the tympanum, and which are distinguished from each other by the epithets *rotunda* and *ovalis.*

FENCE, in *agriculture;* a term signifying any sort of construction raised for the purpose of enclosing land, such as a bank of earth, a ditch, hedge, wall, railing, paling, or any similar kind of erection.

It seems evident that fences only became known, and were recurred to, as the pastoral state of society disappeared; and that during that of the feudal system they were but little necessary. The materials which are most commonly employed in the raising of fences are, earthy substances, living plants of various kinds, stones, bricks, and wood of different sorts. Irón, and even rope, or cord, are likewise occasionally made use of for forming fences.

FENNEL; a common plant, the seeds of which, by cultivation, acquire an agreeable flavour; they are carminative, and are frequently employed in medicine. In Italy, the young sprouts are eaten as a salad, and also in soups. Fennel seed is extensively exported from France to Great Britain, and is said to be employed in this country in the manufacture of gin.

FERMENTATION; the spontaneous changes which vegetable matter undergoes when exposed to ordinary atmospherical temperture. So long as vegetable substances remain in connection with the living plants by which they were produced, the tendency of their elements to form new combinations is controlled; but, as soon as the vital principle is extinct, they become subject to the unrestrained influence of chemical affinity. Owing to the difference in the constitution of different vegetable compounds, however, they are not all equally prone to fermentation; nor is the nature of the change the same in all of them. Thus alcohol, oxalic, acetic, and benzoic acids, may be kept indefinitely without alteration; while others, such as gluten, sugar, starch, and mucilaginous substances are very liable to decomposition. In like manner, the spontaneous change sometimes terminates in the formation of sugar; at another time, in that of alcohol; at a third, in that of acetic acid; and, at a fourth, in the total dissolution of the substance. This has led to the division of the fermentative processes into four distinct kinds, viz., the *saccharine,* the *vinous,* the *acetous,* and the *putrefactive* fermentation. When starch is kept moist for a considerable length of time, a change gradually ensues, and a quantity of sugar equal to about half the weight of starch employed is generated. Exposure to the atmosphere is not necessary to this change, though the quantity of sugar is increased by the access of air.

The conditions requisite for establishing the vinous fermentation are the following, viz., the presence of sugar, water, yeast, and a certain temperature. To observe the chemical changes which occur, we must dissolve five parts of sugar in about twenty of water, adding a little yeast, and, introducing the mixture into a glass flask, furnished with a bent tube, the extremity of which opens under an inverted jar full of water or mercury, apply a temperature of 60° or 70° Fahr., to the materials. In a short time, we shall observe the syrup to become muddy, and a multitude of air bubbles to form around the ferment; these unite, and, attaching themselves to particles of the yeast, rise along with it to the surface, forming a stratum of froth. The yeasty matter will then disengage itself from the air, fall to the bottom of the vessel, to acquire buoyancy a second time, and so on. The fermentation will continue for two or three days, when it will terminate, leaving the impurities to subside, and the liquor clear and transparent.

The only appreciable changes which are found to have occurred during the process, are the disappearance of the sugar, and the formation of alcohol (which remains in the flask), and of carbonic acid which is collected in the inverted jar. The yeast appears to have operated only by bringing on the fermentation, without farther contributing to the products. The atmospheric air, having been excluded by the nature of the apparatus, can have exercised no effect upon the result. The true theory of the process is founded on the fact, that the sugar, which disappears, is precisely equal to the united weights of the alcohol and carbonic acid; and hence the former is supposed to be resolved, during the process, into the two latter. Though a solution of pure sugar is not susceptible of the vinous fermentation, without being mixed with yeast, yet the saccharine juices of plants do not require the addition of that substance; or, in other words, they contain some principle, which, like yeast, excites the fermentative process. Thus the juice of the grape, of the apple, &c., ferments spontaneously, but not without enjoying access to the air; from which it would appear, that it must contain a principle which is convertible into yeast, or, at least, into a compound, which acquires the characteristic property of that substance, by absorbing oxygen.—The various kinds of stimulating fluids, prepared by means of the vinous fermentation, are divisible into wines, which are formed from the juices of saccharine fruits, and the various kinds of ale and beer produced from a decoction of the nutritive grains previously malted.

The juice of the grape is superior, for the purpose

of making wine, to that of all other fruits, not merely in containing a larger proportion of saccharine matter, since this deficiency may be supplied artificially, but in the nature of its acid. The chief or only acidulous principle of the mature grape, ripened in a warm climate, such as Spain, Portugal, or Madeira, is the bitartrate of potash. As this salt is insoluble in alcohol, the greater part of it is deposited during the vinous fermentation; and an additional quantity subsides, constituting the *crust*, during the progress of wine towards its point of highest perfection. The juices of other fruits, on the contrary, such as the gooseberry or currant, contain the malic or citric acids, which are soluble both in water and alcohol, and of which, therefore, they can never be deprived. Consequently, these wines are only rendered palatable by the presence of free sugar, which conceals the taste of the acid; and hence it is necessary to arrest the progress of the fermentation long before the whole of the saccharine matter is consumed. For the same reason, these wines do not admit of being long kept; for as soon as the free sugar is converted into alcohol, by the slow fermentative process, which may be retarded by the addition of brandy, but cannot be prevented, the liquor acquires a strong sour taste.

Ale and beer differ from wines, in containing a large quantity of mucilaginous and extractive matters, derived from the malt with which they are made.—From the presence of these substances, they always contain a free acid, and are greatly disposed to pass into the acetous fermentation. The sour taste is concealed, partly by free sugar, and partly by the bitter flavour of the hop, the presence of which diminishes the tendency to the formation of an acid. The fermentative process which takes place in dough mixed with yeast, and on which depends the formation of good bread, has been supposed, by some, to be of a peculiar kind, and accordingly designated by the name of the *panary fermentation*. More recent researches upon this subject, however, leave little doubt that the phenomena are to ascribed to the saccharine matter of the flour undergoing the vinous fermentation, by which it is resolved into alcohol and carbonic acid. When any liquid has undergone the vinous fermentation, or even pure alcohol, dilated with water, is mixed with yeast, and exposed in a warm place to the open air, the acetous fermentation takes place. This change is attended with an intestine movement, and the developement of heat and carbonic acid gas; the fluid, at the same time, becoming turbid, from the deposition of a peculiar filamentous matter. This process goes on tardily below 60° Fahr.; at 50°, is very sluggish; and at 32°, is wholly arrested. On the contrary, when the temperature is as high as 80°, it proceeds with vigour.

It is necessary to distinguish between the mere formation of acetic acid, and the acetous fermentation. Most vegetable substances yield acetic acid, when they undergo spontaneous decomposition; and inferior kinds of ale and beer are known to acquire acidity in a short time, even when confined in well-corked bottles. These processes, and a variety of others, however, are quite different from the proper acetous fermentation, above described, being unattended with visible movement in the liquid with the absorption of oxygen from the air, or the evolution of carbonic acid. The true acetous fermentation consists in the conversion of alcohol into acetic acid, the quantity of the latter being precisely proportional to that of the former. The nature of the chemical action is, however, at present, obscure.

It has been imagined that pure alcohol contains a greater proportional quantity of carbon and hydrogen than acetic acid; that the oxygen of the atmosphere, the presence of which is indispensable, abstracts so much of those elements, by giving rise to the formation of carbonic acid and water, as to leave the remaining carbon, hydrogen, and oxygen of the alcohol, in the precise ratio for forming acetic acid. The acetous fermentation is conducted on a large scale, for yielding the common vinegar of commerce. In France, it is prepared by exposing weak wines to the air during warm weather. In this country, it is made from a solution of brown sugar or molasses, or an infusion of malt. The vinegar thus obtained, however, always contains a large quantity of mucilaginous and other vegetable matters, the presence of which renders it liable to several ulterior changes. The putrefactive fermentation is confined to those vegetable substances, in which the oxygen and hydrogen exist, in a proportion to form water; and in such, particularly, as contain nitrogen. Those proximate principles, in which carbon and hydrogen prevail, such as the oils, resins, and alcohol, do not undergo the putrefactive fermentation; nor do acids, which contain a considerable excess of oxygen, manifest a tendency to suffer this change. The conditions requisite for enabling the putrefactive process to commence, are moisture, air, and a certain temperature. The temperature most favourable is between 60° and 100° Fahr. The products of the process may be divided into the solid, liquid, and gaseous. The liquid are chiefly water, together with a little acetic acid and oil. The gaseous products are light, carbureted hydrogen, carbonic acid, and, when nitrogen is present, ammonia. Pure hydrogen, and, probably, nitrogen, are sometimes disengaged. Another elastic principle, supposed to arise from putrefying vegetable remains, is the noxious *miasmata* of marshes. The origin of these, however, is exceedingly obscure. The solid product is a dark, pulverulent substance, consisting of charcoal, combined with a little oxygen and hydrogen, which, when mixed with a proper quantity of earth, is called *vegetable mould*.

Ferretto, in the *glass manufacture*, a substance employed to colour glass. This is made by the simple calcination of copper, but it serves for several colours. There are two ways of making it; the first is as follows: take thin plates of copper, and place them on a layer of powdered brimstone, in the bottom of a crucible; over these lay more brimstone, and over that another layer of the plates, and so on alternately till the pot is full. Cover the pot, lute it well, place it in a wind-furnace, and make a strong fire about it for two hours. When it is taken out and cooled, the copper will be found so calcined that it may be crumbled to pieces between the fingers like a friable earth; it will be of a reddish, and in some parts of a blackish colour. This must be powdered and sifted fine for use. The other way is less easy, but it makes a more valuable ferretto. It is this: make a number of stratifications of plates of copper and powdered vitriol, alternately, in a crucible, which place on the floor of the glass furnace near the eye, and let it stand there three days; then take it out, and make a new stratification with more fresh vitriol, and calcine it again as before;

repeat this operation six times, and a most valuable ferretto is produced.

Ferruginous, is applied to any thing partaking of the properties of iron, or containing particles of that metal. It is particularly applied to certain mineral springs, whose water, in their passage along the strata of the earth, meets with the ore of this metal, or with pyritæ containing it, part of which they wash off, and carry with them, and thus become impregnated with the principles thereof. Such are what we call *chalybeate waters.*

Ferrugo; the rust of iron, or a kind of calx found upon its surface. The rust of iron is astringent; it is applied medicinally.

Fesse, in *heraldry;* one of the nine honourable ordinaries of the escutcheon, which it divides horizontally in the middle, and separates the chief from the point. It is supposed to represent a broad girdle or belt of honour, such as those with which knights at arms were anciently girded. It possesses the centre of the escutcheon, and contains in breadth one third part thereof. When the fesse takes up less than its proper breadth, it is called a bar. Fesse-point is the exact centre of the escutcheon.

Festoon, in *architecture;* an ornament of carved wood, in manner of wreathes or garlands hanging down, which was anciently used at the gates of temples and other edifices.

Fever; a disease characterized by an increase of heat, an accelerated pulse, a foul tongue, and an impaired state of several functions of the body. The varieties are numerous. The principal divisions are into continued and intermittent fevers.

Continued fevers have no intermission, but exacerbations come on usually twice in one day. The genera of continued fevers are: 1. *Synocha,* or inflammatory fever, known by increased heat; pulse frequent, strong and hard; urine high coloured; senses not much impaired: 2. *Typhus,* or putrid-tending fever, which is contagious, and is characterized by moderate heat; quick, weak, and small pulse; senses much impaired, and great prostration of strength: 3. *Synochus,* or mixed fever. Intermittent fevers are known by cold, hot, and sweating stages, in succession, attending each paroxysm, and followed by an intermission or remission. There are three genera of intermitting fevers, and several varieties: 1. *Quotidiana;* a quotidian ague. The paroxysms return in the morning, at an interval of about twenty-four hours. 2. *Tertiana;* a tertian ague. The paroxysms commonly come on at mid-day, at an interval of about forty-eight hours. 3. *Quartana;* a quartan ague. The paroxysms come on in the afternoon, with an interval of about seventy-two hours. The tertian ague is most apt to prevail in the spring, and the quartan in autumn.

When these fevers arise in the spring, they are called *vernal;* and when in the autumn, they are known by the name of *autumnal.* Intermittents often prove obstinate, and are of long duration in warm climates; and they not unfrequently resist every mode of cure, so as to become very distressing to the patient, and, by the extreme debility which they thereby induce, often give rise to other chronic complaints. It seems to be pretty generally acknowledged, that marsh miasmata, or the effluvia arising from stagnant water, or marshy ground, when acted upon by heat, are the most frequent exciting cause of this fever. A watery, poor diet, great fatigue, long watching, grief, much anxiety, exposure to cold, lying in damp rooms or beds, wearing damp linen, the suppression of some long accustomed evacuation, or the recession of eruptions, have been ranked among the exciting causes of intermittents; but it is more reasonable to suppose that these circumstances act only by inducing that state of the body which predisposes to these complaints. One peculiarity of this fever is its great susceptibility of a renewal from very slight causes, as from the prevalence of an easterly wind, even without the repetition of the original exciting cause. In this circumstance, intermittents differ from most other fevers, as it is well known that, after a continued fever has once occurred, and been removed, the person so affected is by no means so liable to a fresh attack of the disorder, as one in whom it had never taken place. We have not yet attained a certain knowledge of the proximate cause of an intermittent fever, but a deranged state of the stomach and primæ viæ is that which is most generally alleged.

Each paroxysm of an intermittent fever is divided into three different stages, which are called the *cold,* the *hot,* and the *sweating stages,* or *fits.* The *cold* stage commences with languor, a sense of debility and sluggishness in motion, frequent yawning and stretching, and an aversion to food. The face and extremities become pale, the features shrink, the bulk of every external part is diminished, and the skin over the whole body appears constricted, as if cold had been applied to it. At length the patient feels very cold, and universal rigours come on, with pains in the head, back, loins, and joints, nausea and vomiting of bilious matter; the respiration is small, frequent, and anxious; the urine is almost colourless; sensibility is greatly impaired; the thoughts are somewhat confused; and the pulse is small, frequent, and often irregular. In a few instances, drowsiness and stupor have prevailed in so high a degree as to resemble coma or apoplexy; but this is by no means usual.

These symptoms abating after a short time, the second stage commences with an increase of heat over the whole body, redness of the face, dryness of the skin, thirst, pain in the head, throbbing in the temples, anxiety, and restlessness; the respiration is fuller and more free, but still frequent; the tongue is furred, and the pulse has become regular, hard, and full. If the attack has been very severe, then, perhaps, delirium will arise. When these symptoms have continued for some time, a moisture breaks out on the forehead, and, by degrees, becomes a sweat, and this, at length, extends over the whole body. As this sweat continues to flow, the heat of the body abates, the thirst ceases, and most of the functions are restored to their ordinary state. This constitutes the third stage.

When intermittents continue for any length of time, they are apt to induce other complaints, such as a loss of appetite, flatulency, scirrhus of the liver, dropsical swellings, and general debility, which, in the end, now and then prove fatal, particularly in warm climates; and, in some cases, they degenerate into continued fevers. Relapses are very common to this fever at the distance of five or six months, or even a year. Autumnal intermittents are more difficult to remove than vernal ones, and quartans more so than the other types. It is always desirable to suspend a paroxysm, if possible, not only to prevent

mischief, but also that there may be more time for the use of the most effectual remedies. When, therefore, a fit is commencing, or shortly expected, we may try to obviate it by some of those means which excite movements of an opposite description in the system: an emetic will generally answer the purpose, determining the blood powerfully to the surface of the body; or a full dose of opium, assisted by the pediluvium, &c.; ether also, and various stimulant remedies, will often succeed; but these may perhaps aggravate, should they not prevent the fit; the cold bath, violent exercise, strong impressions on the mind, &c., have likewise been occasionally employed with effect. Should the paroxysm have already come on, and the cold stage be very severe, the warm bath, and cordial diaphoretics in repeated moderate doses, may assist in bringing warmth to the surface: when, on the contrary, great heat prevails, the antiphlogistic plan is to be pursued. In the intermissions, in conjunction with a generous diet, moderate exercise, and other means calculated to improve the vigour of the system, tonics are the remedies especially relied upon. At the head of these we must certainly place the cinchona, which, taken largely in substance, will seldom fail to cure the disease, where it is not complicated with visceral affection.

Febris synocha; inflammatory fever; a species of continued fever, characterized by increased heat; pulse frequent, strong, hard; urine high-coloured; senses not impaired. This fever is so named from its being attended with symptoms denoting general inflammation in the system, by which we shall always be able readily to distinguish it from either the nervous or putrid. It makes its attack at all seasons of the year, but is most prevalent in the spring; and it seizes persons of all ages and habits, but more particularly those in the vigour of life, with strong elastic fibres, and of a plethoric constitution. It is a species of fever almost peculiar to cold and temperate climates, being rarely, if ever, met with in very warm ones, except among foreigners lately arrived; and, even then, the inflammatory stage is of very short duration, as it very soon assumes either the nervous or putrid type. The exciting causes are sudden transitions from heat to cold, swallowing cold liquors when the body is much heated by exercise, too free a use of vinous and spirituous liquors, great intemperance, violent passions of the mind, the sudden suppression of habitual evacuations, and the sudden repulsion of eruptions.

It may be doubted if this fever ever originates from personal infection; but it is possible for it to appear as an epidemic among such as are of a robust habit, from a peculiar state of the atmosphere. It comes on with a sense of lassitude and inactivity, succeeded by vertigo, rigours and pains over the whole body, but more particularly in the head and back; which symptoms are shortly followed by redness of the face and eyes, great restlessness, intense heat, and unquenchable thirst, oppression of breathing, and nausea. The skin is dry and parched; the tongue is of a scarlet colour at the sides, and furred with white in the centre; the urine is red and scanty; the body is costive; and there is a quickness, with a fulness and hardness in the pulse, not much affected by any pressure made on the artery. If the febrile symptoms run very high, and proper means are not used at an early period, stupor and delirium come on, the imagination becomes much disturbed and hurried, and the patient raves violently. The disease usually goes through its course in about fourteen days, and terminates in a crisis, either by diaphoresis, diarrhœa, hæmorrhage from the nose, or the deposit of a copious sediment in the urine; which crisis is usually preceded by some variation in the pulse.

The chief indication in synocha is to lessen the excessive vascular actions by evacuations, and the antiphlogistic regimen. Of the former, by far the most important is blood-letting. Purging is next in efficacy. As the disease advances, however, we must attempt to promote the other discharges, particularly that by the skin. The antiphlogistic regimen consists in obviating stimuli of every kind, so far as this can be done safely; impressions on the senses, particularly the sight and hearing, bodily and mental exertion, &c., must be guarded against as much as possible. The diet should be of the most sparing kind. The stimulus of heat must be especially obviated by light clothing, or even exposing the body to the air, ventilating the apartment, sprinkling the floor with vinegar and water, &c. When the head is much affected, besides the general treatment, it will be proper to take blood locally, have the head shaved and cooled by some evaporating lotion, apply a blister to the neck, and, perhaps, stimulate the lower extremities. In like manner any other organ, being particularly pressed upon, may require additional means to be used for its relief, which will be different in different cases.

Typhus; a species of continued fever, characterized by great debility, a tendency in the fluids to putrefaction, and the ordinary symptoms of fever. It is to be readily distinguished from the inflammatory by the smallness of the pulse, and the sudden and great debility which ensues on its first attack, and in its more advanced stage, by the petechiæ, or purple spots, which appear on various parts of the body, and the fetid stools which are discharged; and it may be distinguished from the nervous fever by the great violence of all its symptoms on its first coming on. The most general cause that gives rise to this disease is contagion, applied either immediately from the body of a person labouring under it, or conveyed in clothes or merchandise, &c.; but it may be occasioned by the effluvia arising from either animal or vegetable substances, in a decayed or putrid state; and hence it is, that, in low and marshy countries, it is apt to be prevalent when intense and sultry heat quickly succeed any great inundation. A want of proper cleanliness and confined air, are likewise causes of this fever; hence it prevails in hospitals, jails, camps, and on board of ships, especially when such places are much crowded, and the strictest attention is not paid to a free ventilation and due cleanliness. A close state of the atmosphere, with damp weather, is likewise apt to give rise to putrid fever. Those of lax fibres, and who have been weakened by any previous debilitating cause, such as poor diet, long fasting, hard labour, continued want of sleep, &c., are most liable to it.

On the first coming on of the disease, the person is seized with languor, dejection of spirits, great depression, and loss of muscular strength, universal weariness and soreness, pains in the head, back, and extremities, and rigours; the eyes appear full, heavy, yellowish, and often a little inflamed; the temporal arteries throb violently, the tongue is dry and parched, respiration is commonly laborious, and interrupted

with deep sighing; the breath is hot and offensive, the urine is crude and pale, the body is costive, and the pulse is usually quick, small, and hard, and now and then fluttering and unequal. Sometimes a great heat, load, and pain are felt at the pit of the stomach, and a vomiting of bilious matter ensues. As the disease advances, the pulse increases in frequency (beating often from 100 to 130 in a minute); there is vast debility, a great heat and dryness in the skin, oppression at the breast, with anxiety, sighing, and moaning; the thirst is greatly increased; the tongue, mouth, lips, and teeth are covered over with a brown or black tenacious fur; the speech is inarticulate, and scarcely intelligible; the patient mutters much, and delirium ensues. The fever continuing to increase still more in violence, symptoms of putrefaction show themselves; the breath becomes highly offensive; the urine deposites a black and fetid sediment; the stools are dark, offensive, and pass off insensibly; hæmorrhages issue from the gums, nostrils, mouth, and other parts of the body; livid spots or petechiæ appear on its surface; the pulse intermits and sinks; the extremities grow cold; hiccoughs ensue; and death at last closes the scene.

When this fever does not terminate fatally, it generally begins, in cold climates, to diminish about the commencement of the third week, and goes off gradually towards the end of the fourth, without any very evident crisis; but in warm climates it seldom continues above a week or ten days, if so long. Our opinion, as to the event, is to be formed by the degree of violence in the symptoms, particularly after petechiæ appear, although in some instances recoveries have been effected under the most unpromising appearances. An abatement of febrile heat and thirst, a gentle moisture diffused equally over the whole surface of the body, loose stools, turbid urine, rising of the pulse, and the absence of delirium and stupor, may be regarded in a favourable light. On the contrary, petechiæ, with dark, offensive, and involuntary discharges by urine and stool, fetid sweats, hæmorrhages and hiccoughs denote the almost certain dissolution of the patient. The appearances usually perceived on dissection are inflammations of the brain and viscera, but more particularly of the stomach and intestines, which are now and then found in a gangrenous state. In the muscular fibres there seems likewise a strong tendency to gangrene.

In the very early period of typhus fever, it is often possible, by active treatment, to cut short the disease at once; but where it has established itself more firmly, we can only employ palliative measures to diminish its violence, that it may run safely through its course. Among the most likely means of accomplishing the first object is an emetic. Attention should next be paid to clear out the bowels by some sufficiently active form of medicine; and, as the disease proceeds, we must keep up this function, and attempt to restore that of the skin, and the other secretions, as the best means of moderating the violence of vascular action. The general antiphlogistic regimen is to be observed in the early part of the disease, as explained under *synocha*. In cases where the skin is uniformly hot and dry, the abstraction of caloric may be more actively made by means of the cold affusion, that is, throwing a quantity of cold water on the naked body of the patient; which measure has sometimes arrested the disease in its first stage; and, when the power of the system is less, sponging the body occasionally with cold water, medicated, perhaps, with a little salt or vinegar, may be substituted as a milder proceeding. But, where the evolution of heat is even deficient, such means would be highly improper; and it may be sometimes advisable to employ the tepid bath, to promote the operation of the diaphoretic medicines. If, under the use of the measures already detailed, calculated as they are to lessen the violence of vascular action, the vital powers should appear materially falling off, recourse must then be had to a more nutritious diet, with a moderate quantity of wine, and cordial or tonic medicines.

There is generally an aversion to animal food, whence the mucilaginous vegetable substances, as arrow-root, &c., rendered palatable by spice or a little wine, or sometimes mixed with milk, may be directed as nourishing and easy of digestion. If, however, there be no marked septic tendency, and the patient cloyed with these articles, the lighter animal preparations, as calves-foot jelly, veal-broth, &c., may be allowed. The extent to which wine may be carried, must depend on the urgency of the case, and the previous habits of the individual; but it will commonly not be necessary to exceed half-a-pint, or a pint at most, in the 24 hours; and it should be given in divided portions, properly diluted, made, perhaps, into negus, whey, &c., according to the liking of the patient. The preference should always be given to that which is of the soundest quality, if agreeable; but where wine cannot be afforded, good malt liquor, or mustard whey, may be substituted.

Some moderately stimulant medicines, as ammonia, aromatics, serpentaria, &c., may often be used with advantage, to assist in keeping up the circulation; also those of a tonic quality, as columba, cusparia, cinchona, &c., occasionally in their lighter forms; but more especially the acids. These are, in several respects, useful: by promoting the secretions of the primæ viæ, &c., they quench thirst, remove irritation, and manifestly cool the body; and in the worst forms of typhus, where the putrescent tendency appears, they are particularly valuable from their antiseptic power; they are also decidedly tonic, and, indeed, those from the mineral kingdom powerfully so. These may be given freely as medicines, the carbonic acid also in the form of brisk fermenting liquors; and the native vegetable acids, as they exist in ripe fruits, being generally very grateful, may constitute a considerable part of the diet. In the mean time, to obviate the septic tendency, great attention should be paid to cleanliness and ventilation, and keeping the bowels regular by mild aperients, or clysters of an emollient or antiseptic nature; and where aphthæ appear, acidulated gargles should be directed. If the disease inclines more to the nervous form, with much mental anxiety, tremors, and other irregular affections of the muscles, or organs of sense, the antispasmodic medicines may be employed with more advantage, as ether, camphor, musk, &c., but particutarly opium, which should be given in a full dose, sufficient to procure sleep, provided there be no appearances of determination of blood to the head; and it may be useful to call a greater portion of nervous energy to the lower extremities by the pediluvium, or other mode of applying warmth, or occasionally by synapisms, not allowing these to

produce vesication. But if there should be much increased vascular action in the brain, more active means will be required; even the local abstraction of blood, if the strength will permit; and it will be always right to have the head shaved, and kept cool by some evaporating lotion, and a blister applied to the back of the neck. In like manner, other important parts may occasionally require local means of relief. Urgent vomiting may, perhaps, be checked by the effervescing mixture; a troublesome diarrhœa by small doses of opium, assisted by aromatics, chalk, ond other astringents, or sometimes by small doses of ipecacuanha; profuse perspirations by the *infusum rosæ*, a cooling regimen, &c.

Nervous Fever; a variety of the *typhus mitior* of Cullen, but by many considered as a distinct disease. It mostly begins with loss of appetite, increased heat and vertigo; to which succeed nausea, vomiting, great languor, and pain in the head, which is variously described, by some like cold water pouring over the top; by others, a sense of weight. The pulse, before little increased, now becomes quick, febrile, and tremulous; the tongue is covered with a white crust, and there is great anxiety about the præcordia. Towards the seventh or eighth day, the vertigo is increased, and tinnitus aurium, cophosis, delirium, and a dry and tremulous tongue take place. The disease mostly terminates about the fourteenth or twentieth day.

Dengue Fever. This name has been given to a disease which appeared in the years 1827 and 1828, in the West Indies, and in the southern States of North America. It has also been called the *dingee, the danga*, the *dandy*, the *bouquet*, and the *bucket* fever. This disease was remarkable for the suddenness of its attack, the great numbers affected, the severity of the symptoms, and the rareness of death from it. It would seem, from the reports of those who have seen most of this disease, and whose judgment may be relied on, that the *dengue* has some affinities with the yellow fever. The symptoms, as noticed in the Havanna, were first great languor, chilliness, and pain in the tendons of the smaller joints: following these were burning heat and redness of the skin, pains in the muscles of the limbs, or pain in the forehead, and a loathing or vomiting of whatever was taken into the stomach. The fever continued for one, two, or three days, and then usually terminated with a free sweating, which freed the patient, likewise, from his pains. But many, after leaving their beds, suffered by a renewal of their pains, which, in some, have become chronic; others have also had a renewed attack of the fever. "The most usual mode of attack, however," says Dr. Stedman, of Santa Cruz, "which appears not a little singular, was the following: A person in perfect health would suddenly feel a stiffness, amounting almost to pain, in one of his fingers, and most frequently his little finger. The stiffness increased, and was accompanied with an intense degree of pain, which spread rapidly over the whole hand, and up the arm to the shoulder. The fingers in both hands, in a few hours, became swelled, stiff, and painful, preventing all attempts at bending the joints." To this succeeded restlessness, depression of spirits, nausea, vomiting, shivering, great heat, intense headache, and most acute pain in every joint. The most distressing symptoms were intense pain in the eye-balls and back, the eyes seeming to the patient enlarged, filling the sockets, and as if ready to burst. Quite a remarkable symptom was the feeling of intense cold, while, at the same time, the skin was intensely hot. These symptoms continued from 24 to 36 hours. The patient now remained languid, irritable, and restless for about three days, when it was not uncommon for a new attack to come on, accompanied by an efflorescence, beginning at the palms of the hands, and extending thence over the whole body. Secondary symptoms, consisting principally in pain and stiffness of the limbs and body, followed, which, in many cases, continued even weeks, and made the patient most uncomfortable. Sometimes there was distressing itching; and, in some cases, there was swelling of the prepuce and scrotum, and, in others, a discharge from the urethra, resembling gonorrhœa. Dr. Stedman considers the disease, contagious. The treatment was, for the most part, antiphlogistic. Such means were used as would hasten the sweating stage, evacuate the bowels, and render the patient most comfortable. Where these means failed, the more active depleting means were resorted to, and much relief of local suffering was afforded by the use of blisters and stimulating embrocations, mustard poultices, and the like. The latter was applied to the temples, to relieve the pain in the eye-balls, to the back, the back of the neck, &c., as indicated, and always with advantage. Dr. Stedman found benefit from blood-letting, in some severe cases.

Synochus; a mixed fever; a species of continued fever, commencing with symptoms of synocha, and terminating in typhus, the former being apt to preponderate at its commencement, and the latter towards its termination. Every thing which has a tendency to enervate the body may be looked upon as a remote cause of this fever; and, accordingly, we find it often arising from great bodily fatigue. too great an indulgence in sensual pleasures, violent exertions, intemperance in drinking, and errors in diet, and now and then likewise from the suppression of some long accustomed discharge. Certain passions of the mind (such as grief, fear, anxiety, and joy) have been enumerated among the causes of fever, and, in a few instances, it is probable they may have given rise to it; but the concurrence of some other powers seems generally necessary to produce this effect.

The most usual and universal cause of this fever is the application of cold to the body; as, for instance, when the body is deprived of a part of its accustomed clothing, or a particular part is exposed while the rest is kept at its usual warmth, or a sudden and general exposure to cold takes place when the body is heated much above its usual temperature. Another frequent cause of fever seems to be breathing air contaminated by the vapours arising either directly or originally from the body of a person labouring under the disease. A peculiar matter is supposed to generate in the body of a person affected with fever, and this, floating in the atmosphere, and being applied to one in health, will, no doubt, often cause fever to take place in him; which has induced many to suppose, that this infectious matter is produced in all fevers whatever, and that they are all more or less contagious. The effluvia arising from the human body, if long confined to one place, without being diffused in the atmosphere, will, it is well known, acquire a singular virulence, and will, if applied to the bodies of men, become the cause of

fever. Exhalations, arising from animal or vegetable substances in a state of putrefaction, have been looked upon as another general cause of fever; marshy or moist grounds, acted upon by heat for any length of time, usually send forth exhalations, which prove a never-failing source of fever, particularly in warm climates.

An attack of this fever is generally marked by the patient's being seized with a considerable degree of languor or sense of debility, together with a sluggishness in motion, and frequent yawning and stretching; the face and extremities at the same time become pale, and the skin over the whole surface of the body appears constricted; he then perceives a sensation of cold in his back, passing from thence over his whole frame; and, this sense of cold continuing to increase, tremours in the limbs and rigours of the body succeed. There is also a loss of appetite, want of taste in the mouth, slight pains in the head, back, and loins, with small and frequent respirations. The sense of cold and its effects, after a little time, become less violent, and are alternated with flushings; and at last, going off altogether, they are succeeded by great heat diffused generally over the whole body; the face looks flushed, the skin is dry, as likewise the tongue; universal restlessness prevails, with a violent pain in the head, oppression at the chest, sickness at the stomach, and an inclination to vomit. There is likewise a great thirst and costiveness, and the pulse is full and frequent, beating, perhaps, 90 or 100 strokes in a minute. When the symptoms run very high, and there is a considerable determination of blood to the head, delirium will arise. In this fever, as well as most others, there is generally an increase of symptoms towards evening.

As a fever once produced will go on, although its cause be entirely removed, and as the continued or fresh application of a cause of fever will neither increase that which is already produced, nor occasion a new one, there can be no certainty as to the duration of fever; and it is only by attending to certain appearances or changes which usually take place on the approach of a crisis, that we can form any opinion or decision. The symptoms pointing out the approach of a crisis, are, the pulse becoming soft, moderate, and near its natural speed; the tongue losing its fur, and becoming clean, with an abatement of thirst; the skin being covered with a gentle moisture, and feeling soft to the touch; the secretory organs performing their several offices; and the urine depositing flaky crystals of a dirty red colour, and becoming turbid on being allowed to stand any time.

A simple continued fever terminates always by a regular crisis, in the manner before mentioned, or, from the febrile matter falling on some particular parts, it excites inflammation, abscess, eruption, or destroys the patient. This disease being of a mixed nature, the treatment must be modified accordingly. In the beginning, the same plan is to be pursued as in synocha, except that we must be more sparing in the use of the lancet, in proportion as there is less power in the system to maintain the increased action of the heart and arteries; although, if any important part should be much affected, we must act more vigorously, to prevent its disorganization, and the consequent destruction of life. When the character of the disease is changed, the remedies will be such as are pointed out under the head of *Typhus*.

FIBRE, in *anatomy*; a simple filament which is supposed to consist of earthy particles, connected together by an intermediate gluten. Fibres are distinguished, according to their position and course, into direct, transverse, and oblique; and by their different arrangement are formed the membranes, muscles, vessels, nerves, &c. Those fibres which compose muscles are called muscular; those which form nerves, nervous; the rest are distinguished into *carneous* or fleshy, and *osseous* or bony.

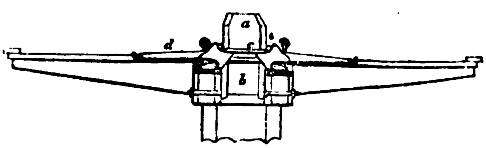
FIBRIN; a peculiar organic compound, found both in vegetables and animals. It is a soft solid, of a greasy appearance, insoluble in water, which softens in the air, becoming viscid, brown, and semi-transparent. On hot coals it melts, throws out greasy drops, crackles, and evolves the smoke and odour of roasting meat. It is procured, in its most characteristic state, from animal matter. It exists in chyle; it enters into the composition of blood; and it forms the chief part of muscular flesh; and hence it must be regarded as the most abundant constituent of the soft solids of animals. According to the analysis of MM. Gay-Lussac and Thénard, it is composed of carbon 53.36, nitrogen 19.934, oxygen 19.685, and hydrogen 7.021

FIBULA, in *anatomy*; a long bone of the leg situated on the outer side of the tibia, and forming, at its lower end, the outer ancle.

FIBULA, in *surgery*; a needle with which wounds are sewed together.

FIBULA, in *architecture*; an iron cramp with which square stones are held together.

FID; an instrument for supporting the upper mast of a ship, by means of levers adapted to frames or carriages of iron, attached to the upper cross-trees. The contrivance we have represented beneath has been the source of a large fortune to its inventor.



The heel of the topmast is shown at *a*, and *d* represents the levers, on the shorter arms of which the fid-plate, *c*, rests. The top of the lower mast is shown at *b*. When the mast is to be lowered, the longer arms of the levers are pressed downwards and the fid-plate removed.

FIELD, in *heraldry*; the whole surface of the shield or escutcheon; so called, probably, because it bore the achievements which were worn in the field of battle.

FIELD PIECES; small cannons, from 3 to 12 pounders, carried with an army. *Field staff*; a staff carried by the gunners, about the length of a halbert, with a spear at one end, having on each side ears screwed on, like the cock of a matchlock, into which the bombardiers screw lighted matches when they are upon command; and then the field staffs are said to be armed.

FIELD WORKS, in *fortification*, are those thrown up by an army in besieging a fortress, or by the besieged to defend the place; as the fortifications of camps, highways, &c.

FIFE; a wind instrument of the martial kind, consisting of a short, narrow tube, with holes disposed along the side, for the regulation of its tones.

FIFTH, in *music*; a distance comprising four diatonic intervals, that is, three tones and a half. *Fifth sharp* is an interval consisting of eight semitones.

FIGURATE NUMBERS; an arithmetical amusement much in vogue at the beginning of the seventeenth century. Jac. Bernouilli, and particularly Wallis in his *Arith. Infinit.*, and L'Huilier, in his *Algebra*, have made it a subject of investigation. These numbers are formed by the terms of arithmetical series, of all sorts, in which the first member is always unity. For example:—

I.—1,	2,	3,	4,	5,	6,	&c.
II.—1,	3,	6,	10,	15,	21,	&c.
III.—1,	4,	9,	16,	25,	36,	&c.
IV.—1,	5,	12,	22,	35,	51,	&c.

Those in the second row are called *triangular* numbers, because their units may be arranged in pure equilateral triangles; the members of the third row are called *square* numbers; those of the fourth *pentagonal*, &c.; and so there are also *hexagonal, heptagonal*, and, in general, *polygonal* numbers. If the terms of the polygonal series are again added, in succession, we obtain other orders, as the members of each of the rows are called; thus,

a.—1,	3,	6,	10,	15,	21,	&c.
b.—1,	4,	10,	20,	35,	56,	&c.
c.—1,	5,	14,	30,	55,	91,	&c.
d.—1,	6,	18,	40,	75,	126,	&c.,

are pyramidal numbers, because, by placing over one another the polygonal numbers in the order in which they are added, so that the smaller come over the next larger of the same sort, regular pyramids are formed. Thus the members of the row *a* form triangular, of the row *b* quadrangular, and of the row *c* pentagonal pyramids.

FILAMENTS, in *anatomy*; the small fibres or threads which compose the texture of the muscles.

FILE, in *heraldry*; the straight line in a label, from which the several points issue.

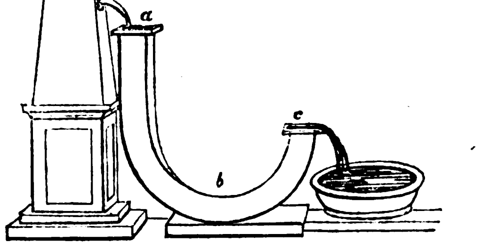
FILE, in *military* language; any number of men drawn up in a straight line behind each other.

FILLAGREE WORK; a kind of ornamental work in gold or silver, wrought delicately, in the manner of little threads or grains, or of both intermixed. In Sumatra manufactures of this kind are carried to very great perfection, though the tools made use of are very coarse and clumsy. The workmen melt the gold in a crucible of their own forming, and, instead of bellows, they blow with their mouths through a piece of bamboo. They draw and flatten the wire in a manner similar to that adopted by Europeans. It is then twisted, and thus a flower, or the shape of a flower, is formed. A pattern of the flowers or foliage is prepared on paper, of the size of the gold plate on which the fillagree is to be laid. According to this they begin to dispose on the plate the larger compartments of the foliage, for which they use plain flat wire of a larger size, and fill them up with the leaves. A gelatinous substance is used to fix the work, and, after the leaves have been placed in order, and stuck on, bit by bit, a solder is prepared of gold filings and borax, moistened with water, which is strewed over the plate; and, after being put into the fire a short time, the whole becomes united. When the fillagree is finished, it is cleansed with a solution of salt and alum in water. The Chinese make most of their fillagre of silver, which looks very well, but has not the extraordinary delicacy of Malay work.

FILLET, in *architecture*, is a small square or flat moulding. (See ARCHITECTURE.)

FILTER. The very great utility of filters for domestic purposes must be evident, as a fluid fit for culinary use can through their means be obtained from any source, however muddy or impure, and it must be a desideratum in such contrivances to combine the cheap, the durable, and the efficacious;—to this end a vast variety have been invented, many possessing great advantages. The filter in most general use is a basin formed of some porous kind of stone, and supported over any convenient vessel to catch the percolating fluid. The foul water, being poured into the basin, insinuates itself by slow degrees through the minute pores of the stone, and is collected, drop by drop, in the receptacle placed beneath. This apparatus answers the purpose perfectly well for a time, but has its defects; the constant accumulation of the impurities, after a little while, chokes up the pores of the stone, and, although at first this may be amended by washing, yet ultimately the fine particles insensibly sink down into the stone, the pores become filled, and no water passes. There is also an error noticeable in the form of the vessel, which is in general hemispherical; in this the pressure of the fluid is greatest at the lowest points, and gradually diminishes in every other part; so that, unless the pressure is greater at the centre than it ought to be, scarcely any water will pass through the other parts. A more eligible form would be that of a cylinder, formed either of earthenware or metal, with a circular plate of the filtering stone cemented into the middle; by this means the pressure on all parts would be equal: it would possibly possess another advantage, that of cleansing itself; for, when the water ceased to flow with freedom on the one side, it might be inverted, and then the mere act of filtration would remove the matter deposited on the other side.

One of the simplest modes of constructing a useful filter is shown in the diagram beneath.



It consists of a tube, *a b c*, bent like a syphon, but inverted. In this is placed a quantity of sand, through which the filtration occurs. By its gravity it descends from *a* to *b*, and, as fluids always have a tendency to

a state of equilibrium, it rises in the opposite arm of the bent tube, whence it passes out in a pure state. A small piece of wood, with holes pierced through it, should be placed on the sand at the larger end.

A very clean and useful patent filter may now be described. One of the leading features of this invention appears to be the construction of vessels which are to be employed for filtering water for domestic uses, by combining slabs of slate, and the other is passing the water upwards in a zigzag course through layers or beds of sand and other purifying matters.

These slabs of slate are to be cemented together at the joints, by a mixture of white lead, or a strong mortar made of lime; and the slabs are to be farther supported and braced together, to prevent their separating, by rods of iron passed through the vessel, and secured by nuts screwed on the outsides.

The form of the vessel is proposed to be square, or at least rectangular, and twice as high as the breadth of the base, the internal part being divided into five compartments, by gratings or perforated plates. The water is to be introduced into the lowest compartment, by a pipe leading from a reservoir placed in an elevated situation, in order that the pressure from above may cause the water to rise through the filter to the top.

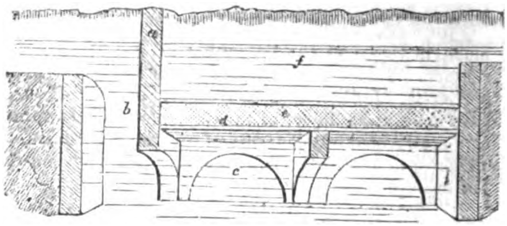
The lowest compartment, or receiving vessel, is covered by a grating, upon which, occupying the second compartment, a quantity of sand is placed. The water is therefore to percolate through the sand upward, and deposit any foul matter with which it may be impregnated in the bed of sand. Above the second compartment a plate is fixed, with conical holes in the centre, through which the water is made to pass, by the upward pressure, into the third compartment, which is likewise filled with sand. The part above this third compartment is perforated towards one side only, so that the water, in passing upwards, has to proceed through the bed of sand partly in a horizontal direction.

The fourth compartment is occupied with sand and carbonaceous matter, such as broken pieces of charcoal, burnt brick, or unglazed pottery ware, which not only takes up the foul matter mechanically, but also acts chemically upon the water, to sweeten and purify it from any animal matter which it may contain. The plate above the compartment is perforated with conical holes towards the opposite sides of the lower plate, for the purpose, as before stated, of causing the water to percolate through the bed, partly in a horizontal direction, and, by thus giving it a zigzag course, to bring it in contact with a more extended bed of the purifying material than it would be exposed to if it passed directly upwards.

The fifth compartment contains broken pieces of slag from the foundry; and from this compartment, which is at the top of the filtering vessel, the purified water is to be drawn off for use.

In constructing a filtering apparatus of large capacity, it is proposed to make its sides with brick, or in some cases with iron, properly secured together; but the plan of a slate frame secured by external bars of iron is by far the most cleanly that can be devised.

A process for filtering water on the large scale has been some time employed on the banks of the Seine, for the use of Paris; and an arrangement producing similar results, though on a comparatively small scale, is now going on at Hammersmith. We give a diagram of a cheap apparatus for extensive filtration beneath.



The wall *a* serves to separate the water to be filtered from the reservoir holding the pure water. The fluid, descending at *b*, enters beneath the arches *c*. These serve to support an extensive frame-work, either of wood or metal, on which are placed large fragments of stone. The pieces are diminished in size in ascending towards the upper strata, till, on arriving at about *e*, sand takes the place of larger masses. A second frame-work, or sheet of canvass, separates the filtering materials from the pure water at *f*.

Finale; the concluding part of a musical composition; for instance, of a quartetto, of a symphony, of any act of an opera, of a ballet, &c. It consists of compositions of various characters. The finale, in instrumental pieces, has mostly a character of vivacity, and requires a quick movement and lively performance. In the opera, the finale mostly consists of a series of compositions for many voices, and of different character and different time and movement.

Fine Arts. See Arts, Fine.

Finger-Board; that thin, black covering of wood laid over the neck of a violin, violoncello, &c., and on which, in performance, the strings are pressed by the fingers of the left hand, while the right manages the bow.

Fingering; disposing of the fingers in a convenient, natural, and apt manner in the performance of any instrument, but more especially the organ and piano-forte. Good fingering is one of the first things to which a judicious master attends. It is, indeed, to this that the pupil must look as the means for acquiring a facile and graceful execution, and the power of giving passages with articulation, accent, and expression. Easy passages may be rendered difficult, and difficult ones impracticable, by bad fingering; and, though there are many arrangements of notes which admit of various fingering, still, even in these, there is always one best way of disposing of the hand, either with regard to the notes themselves, or those which precede or follow them. But there are an infinite number of possible dispositions of notes, which can only be fingered in one particular way; and every attempt at any other is but endangering the establishment of some awkwardness, which the practitioner will have to unlearn before he can hope to attain the true fingering. Hence it is obvious that no qualification requisite to good performance is of more importance to the learner than that of just fingering, and that, whatever talents and assiduity may be able to achieve independent of instruction, in this great particular the directions of a skilful master are indispensable.

Finery; the furnace in which the operation of refining metals is performed.

Finite, in *mathematics*; an epithet for a series, line, &c., which is bounded or limited in extent, duration, &c., in contradistinction to infinite.

Fire. The all-consuming energy of fire, the first and most important agent of civilization, the similarity of its effects to those of the sun, its intimate connection with light, its terrible and yet beneficent power, the beauty of the constantly changing flame, its many colours and shapes,—easily explain how it happened that, in times when cause and effect, form and essence, were not yet distinctly separated, fire became an object of religious veneration, a distinguished element in mythology, an expressive symbol in poetry, and an important agent in the systems of cosmogony. It obtained a place among the elements, and was for a long time considered to be a constituent part in the composition of all bodies, and to require only the concurrence of favourable circumstances to develope its activity. It was early thought that fire showed itself in its elementary form in electrical phenomena. At a later period, it was believed to be the source of all chemical action, and, as such, was called *phlogistique*. It was finally confounded with light, and became, as it were, the principal agent of the universe. Those agents, differing in their qualities from other bodies, and sometimes called *imponderable* agents, under whatever light they may be viewed, open a vast field for speculation; and it is not surprising that some philosophers should have seen only different modifications of the same matter, where others have thought to recognise the influence of different kinds of matter; thus the effects of fire have been attributed to a vibratory motion of the particles of matter, or to the undulations of ether. When natural philosophy was treated in the schools, theories were adopted to which little attention is paid in the present age, when all science is founded on facts and observations. Caloric, be it a material agent or the consequence of vibratory motion, is at present considered the cause of the phenomena which were formerly ascribed to fire. Nevertheless, the nature of the one is as unknown to us as that of the other was to the ancients. The substitution of one of these terms for the other has, however, introduced a greater precision of language, and cause and effect are no longer confounded under the same name. (See Caloric and Combustion.)

The word *fire*, with different epithets, or *ignis* (Latin), has been used for the spontaneous or casual combustion of gaseous substances. Such is the *ignis fatuus*, the Jack-with-the-lantern, or Will-with-the-wisp, observed in places where animal matter is in a state of putrefaction. Such are also the exhalations called *fire-damps*, which is indeed a most unphilosophical term, as there is no damp in the matter. They are frequently seen in coal mines, and are kindled by the approach of flame, and produce terrible explosions, which may be prevented by currents of air, or more completely by Sir Humphry Davy's safety-lamp. The former phenomenon is attributed to phosphureted hydrogen gas, which takes fire on exposure to the atmosphere, and the latter to carbureted hydrogen gas, which, when mixed with a certain proportion of atmospheric air, and brought into contact with burning bodies, explodes. (See Mine.)

The warm springs, the existence of extinct volcanoes, the effects of those still in activity, and the fact that the temperature of the earth becomes warmer the deeper we descend, have induced many philosophers to adopt the idea of subterranean fires, or of a central fire. According to the former hypothesis, there are combustible materials, in a state of ignition, in the bowels of the earth, which produce the heat indispensable for the production of the above-mentioned phenomena. The latter hypothesis supposes that the globe was once in a state of igneous fusion, that the surface has gradually become solid by cooling, and that the interior of the earth is still liquid and hot, and may remain so for ever, if the heat received from the sun should continue.

Fire-Balls. It is a fact that has been long known, that clays and also several other incombustible substances, when mixed with sea-coal in certain proportions, cause the coal to give out more heat in its combustion than it can be made to produce when it is burned pure or unmixed; but the cause of this increase of heat does not appear to have been yet investigated with that attention which so extraordinary and important a circumstance seems to demand.

Daily experience teaches us that all bodies, those which are incombustible as well as those which are combustible and actually burning, throw off in all directions heat, or rather calorific (heat-making) rays, which generate heat wherever they are stopped or absorbed; but common observation was hardly sufficient to show any perceptible difference between the quantities of calorific rays thrown off by different bodies when heated to the same temperature, or exposed in the same fire, although the quantities so thrown off might be, and probably are, very different.

It has lately been ascertained that when the sides and back of an open chimney fire-place in which coals are burned are composed of fire-bricks, and heated red hot, they throw off into the room incomparably more heat than all the coals that could possibly be put into the grate, even supposing them to burn with the greatest possible degree of brightness. Hence it appears that a red-hot burning coal does not send off near so many calorific rays as a piece of red-hot brick or stone of the same form and dimensions; and this interesting discovery will enable us to make some very important improvements in the construction of our fire-places, and also in the management of our fires.

The fuel, instead of being employed to heat the room directly or by the direct rays from the fire, should be so disposed, or placed, as to heat the back and sides of the grate, which must be always constructed of fire-brick or fire-stone, and never of iron or of any other metal. Few coals, therefore, when properly placed, make a much better fire than a larger quantity; and shallow grates, when they are constructed of proper materials, throw more heat into a room, and with a much less consumption of fuel, than deep grates; for a large mass of coals in the grate arrests the rays which proceed from the back and sides of the grate, and prevents their coming into the room; or, as fires are generally managed, it prevents the back and sides of the grate from ever being sufficiently heated to assist much in heating the room, even though they be constructed of good materials, and large quantities of coals be consumed in them.

It is possible, however, by a simple contrivance, to make a good and economical fire in almost any grate, though it would always be advisable to construct fire-places on good principles, or to improve them by judicious alterations, rather than to depend on the use of additional inventions for correcting their defects.

To make a good fire in a bad grate, the bottom of the grate must first be covered with a single layer of

balls, made of good fire-bricks, or artificial fire-stone, well burnt, each ball being perfectly globular, and about 2½ or 2¾ inches in diameter. On this layer of balls the fire is to be kindled, and, in filling the grate, more balls are to be added with the coals that are laid on; care must, however, be taken in this operation to mix the coals with the balls well together, otherwise, if a number of the balls should get together in a heap, they will cool, not being kept red-hot by the combustion of the surrounding fuel, and the fire will appear dull in that part; but if no more than a due proportion of the balls are used, and if they are properly mixed with the coals, they will all, except it be those perhaps at the bottom of the grate, become red hot, and the fire will not only be very beautiful, but it will send off a vast quantity of radiant heat into the room, and will continue to give out heat for a great length of time. It is the opinion of several persons, who have for a considerable time practised this method of making their fires, that more than one-third of the fuel usually consumed may be saved by this simple contrivance. It is very probable that, with careful and judicious management, the saving would amount to one-half, or fifty per cent.

As these balls, made in moulds and burnt in a kiln, would cost very little, and as a set of them would last a long time, probably several years, the saving of expense in heating rooms by chimney fires with bad grates, in this way, is obvious; but still it should be remembered that a saving quite as great may be made by altering the grate, and making it a good fire-place.

In using these balls, care must be taken to prevent their accumulating at the bottom of the grate; as the coals go on to consume, the balls mixed with them will naturally settle down towards the bottom of the grate, and the tongs must be used occasionally to lift them up. And, as the fire becomes low, it will be proper to remove a part of them, and not to replace them in the grate till more coals are introduced: a little experience will show how a fire made in this manner can be managed to the greatest advantage, and with the least trouble.

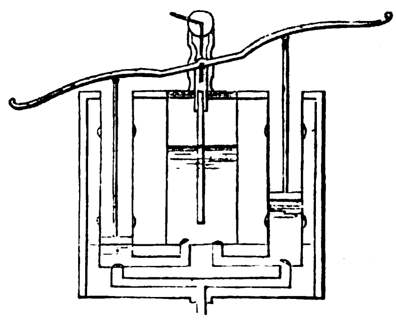
Balls made of any kind of well-burnt hard brick, though not equally durable with fire-brick, will answer very well, provided they are made perfectly round; but, if they are not quite globular, their flat sides will get together, and, by obstructing the free passage of the air amongst them and amongst the coals, will prevent the fire from burning clear and bright.

The best composition for making these balls, when they are formed in moulds, and afterwards dried and burnt in a kiln, is pounded crucibles, mixed up with moistened Stourbridge clay; but good balls may be made with any very hard burnt common bricks, reduced to a coarse powder, and mixed with Stourbridge clay, or even with common clay. The balls should always be made so large as not to pass through between the front bars of a grate.

These balls have one advantage which is peculiar to them, and which might perhaps recommend the use of them to the curious, even in fire-places constructed on the best principles; they cause cinders to be consumed almost entirely,—and even the very ashes may be burnt, or made to disappear, if care be taken to throw them repeatedly upon the fire when it burns with intense heat. It is not difficult to account for this effect in a satisfactory manner; and in accounting for it we shall explain a circumstance on which it is probable that the great increase of the heat of an open fire, where these balls are used, may in some measure depend. The small particles of cinder which, in a common fire, fall through the bottom of the grate and escape combustion, when these balls are used, can hardly fail to fall and lodge on some of them; and, as they are intensely hot, these small bodies which alight upon them in their fall, are soon heated red hot, and disposed to take fire and burn; and as fresh air from below the grate is continually making its way upwards amongst the balls, every circumstance is highly favourable to the rapid and complete combustion of these small inflammable bodies. But, if these small pieces of coal and cinder should in their fall happen to alight on the metallic bars which form the bottom of the grate (as these bars are conductors of heat, and on account of that circumstance as well as of their situation below the fire, they never can be made very hot), any small particle of fuel that happens to come in contact with them not only cannot take fire, but would cease to burn should it arrive in a state of combustion.

Fire-Dress; a new invention of the Chevalier Aldini, which is stated to be an effectual protection against fire, in the reports of committees of the highest respectability appointed to examine it at Paris. It enables the wearer (as has been demonstrated by public experiments) to approach with impunity, or even to pass through a fierce flame, to rescue lives or portable valuable property, or to use means for the extinction of fire. It consists of an exterior light armour of metallic gauze, and of an inner covering of a material which is a slow conductor of heat. Amongst flexible fibrous substances capable of being spun and woven into tissues, the asbestos possesses pre-eminently the property of slowly conducting heat; but the other fibrous matters in common use for the purpose of clothing, such as wool, cotton, &c., may, by immersion in certain saline solutions, be rendered very imperfect conductors, so as to fit them very sufficiently for preventing the transmission of injurious heat to the body, during a temporary exposure of some minutes to the action of flame on the outward covering of wire gauze.

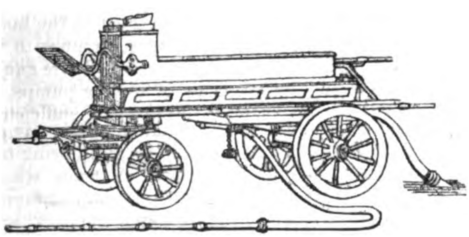
Fire-Engines are a species of forcing pumps, in which the water is subjected to pressure sufficiently strong to raise it to the required height. A fire engine of the best form is shown beneath.



In order to remedy the intermission of the jets which would result from the simple forcing pump, and to produce the discharge of a continuous stream, a vessel filled with air is attached to the engine. The water is forced into this vessel by two forcing pumps, and the air contained therein being condensed, it reacts on the water with a power proportioned to the

condensation. Thus, if the air is condensed one-third, its elasticity will be three times greater than that of the atmosphere, and it will raise water in a tube to the height of 66 feet. The spouting pipe for directing the water upon the fire proceeds from the common air vessel. The handles are so disposed that while the piston of one pump is up, that of the other is down; and they are elongated for the purpose of enabling a great number of men to work them at the same time, so that they may throw a large quantity of water. In Newsham's engines, two cylinders, constructed like forcing pumps, are worked by the reciprocating motions of transverse levers, to which the handles are attached. In this way the water is forced into the air vessel, from which it afterwards spouts through a moveable pipe. In some engines, a single cylinder is used, the piston rod passing through a tight collar, and alternately receiving and expelling the water at each end of the cylinder. In Rowntree's engine, and some others, a part of the inside of a cylinder is traversed by a partition like a door hinged upon the axis of the cylinder, which drives the water successively from each side of the cylinder into the air-vessel. The *hose*, a long flexible tube, made of leather, is of great use in carrying the spouting orifice near to the flames, and thus preventing the water from being scattered too soon. It also serves an important purpose in bringing water from distant reservoirs, by suction created in the pumps of the engine.

Having described several forms of the fire-engine, we may now direct the reader's attention to an external view of the one usually employed. It consists of two cylinders concealed in a box, and, as is shown in the previous page, provided with pistons fitting air-tight. The hose is seen to pass from beneath, and the jet-pipe is a long tube for directing the water. It is shown on the ground.



The steam fire-engine by Mr. Braithwaite is of recent invention. It is an ingenious application of the moving power of steam to the working of fire-engines. The mechanical arrangement consists of two cylinders, the one of 7 inches diameter, being the steam cylinder, and the other of 6½ inches diameter, being the water pump. By the horizontal position of the two cylinders, the parallel motion is easily produced. The boiler is on the construction and principle of Braithwaite and Ericson's patent steam generator. This engine will deliver about 9000 gallons an hour to an elevation of 90 feet, through an adjutage of ⅞ inch. The time of getting the machine into action, from the moment of igniting the fuel (the water being cold), is 18 minutes. As soon as an alarm is given, the fire is kindled, and the bellows, attached to the engine, are worked by hand. By the time the horses are harnessed in, the fuel is thoroughly ignited, and the bellows are then worked by the motion of the wheels of the engine. By the time of arriving at the fire, preparing the horses, &c., the steam is ready. The expense of fuel is stated to be sixpence per hour.

Fire, Greek, was invented in the 7th century. When the Arabs besieged Constantinople in 668, the Greek architect Callinicus of Heliopolis deserted from the caliph to the Greeks, and took with him a composition which, by its wonderful effects, struck terror into the enemy, and forced them to take to flight. Sometimes it was wrapped in flax attached to arrows and javelins, and so thrown into the fortifications and other buildings of the enemy, to set them on fire. At other times, it was used in throwing stone balls from iron or metallic tubes against the enemy. The use of this fire continued at least until the end of the 13th century: but no contemporary writer has handed down to us any accurate account of its composition. To judge from its effects, neither naphtha, sulphur, nor rosin, was a principal ingredient; but saltpetre probably was. It does not appear, from the accounts of the ancients, that it burned *under* water, as has been supposed, but merely that it burned *upon* it. Cardian invented a species of fire of this description. According to a notice in the *Magazin der Erfindungen* (Magazine of Discoveries), the Baron Von Aretin of Munich has discovered in a Latin MS. of the 13th century, in the central library in that city, a dissertation on the Greek fire, which contains the receipt for its composition, so long supposed to be lost.

Fire-Escape. Among the various expedients for facilitating the escape of persons in danger from fire, one of the earliest appears to have been the employment of ladders. But, unfortunately, it too often happens, that when they are wanted, nobody remembers where they are, or will take the trouble to fetch them.

About the year 1810, Mr. Davis invented a very excellent machine on the ladder principle, for which he was deservedly rewarded by the Society of Arts with a donation of 50 guineas. It consisted of three ladders, of moderate length, sliding into each other, and supported perpendicularly on a low carriage with four wheels. By the mechanical arrangements of the machine, these ladders were capable of being inclined at any required angle, and projected with great facility one above the other, so as to form a single ladder, of sufficient length to reach the upper windows of ordinary houses. For the greater security of persons descending the ladders, they were furnished with hand-rails on each side, and at the upper extremity of the machine a pulley and ropes were fixed, by which either persons or goods might be lowered in a basket. Another advantage connected with this apparatus was, that it would enable the firemen to elevate the engine-hose, and direct the branch *horizontally* at any required height by means of guide-ropes, so that the whole force of the stream might be brought to bear upon the flames in an upper apartment, instead of the mere force of descent which the water exerts, under ordinary circumstances, by its fall from the apex of the parabolic curve described by the jet.

Several improvements were subsequently made on this invention by Mr. Gregory, and it was still farther simplified by Mr. Hudson, the philanthropic projector of the Society for Preventing the Loss of Life by Fire.

Mr. Doyle has adapted a series of intersecting levers to the construction of a fire-escape. The principle upon which this machine is constructed, is identical with that of an instrument known by the name of the *lazy tongs*. The instrument consists of a combination of levers of the first kind, crossing each other like the two sides of a pair of scissors, and moving on joints at their extremities and at the points of intersection. The effect of this arrangement is, that when the handles or lower arms of the system of levers are fully extended, the instrument is contracted into a very small compass, but is extended to a considerable length when the handles are brought together. In Mr. Doyle's fire-escape two such instruments as we have described were connected by transverse bars, so as to form a kind of open frame-work, which supported a railed platform. The whole apparatus may be placed on a small carriage, but by simply turning a handle, the platform can in a moment be projected to an altitude of about forty feet.

A fire-escape of a very simple construction has been suggested by Mr. Charles M. Willich, to the Society of Arts. The idea is not new, as blankets have been often used with success; but if the plan pointed out by Mr. W. were adopted, and a system established, many lives might be saved. It consists of a horse-hair net, about 14 feet long, by 8 wide. He recommended that every police station should be furnished with one, which on an alarm of fire should be immediately brought to the spot. The manner of using the net is self-evident. There are always a sufficient number of persons present, who would hold it extended. Horse-hair is recommended, on account of its durability and elasticity. A fire-escape must be *always* perfect, and at hand speedily, or it is useless.

FIRE-PLACE. We often see old fire-places of an enormous size, capable of containing seats, and having the sides at right angles with the back, which is perpendicular. This construction was attended with very great loss of heat, as the size of the mouth occasioned a great current of air up the chimney, and, consequently, into the room; and almost all the radiated and conducted heat was carried off. The application of modern practical science to the comfort of common life has been of the greatest benefit in this respect. Wood is still the principal fuel in the United States; but coal is in some districts now coming into general use. The arrangement need not be essentially different whichever kind of fuel is employed. It is advantageous to make the perpendicular height of the fuel as great as is consistent with safety. A stratum of coals, or ignited wood, will radiate more heat into the lower part of the room, if placed vertically, than if laid horizontally. The fuel should also be so divided as to be easy of ignition, and so placed as to give free access of the air to all its parts, as the smoke is then more likely to be burnt.

Franklin's stoves are cast-iron fire-places, and, when executed according to the inventor's directions, are a very economical contrivance. Most of the articles, however, now sold under this name, are very different from the original plan. Underneath and behind the fire-place is an air chamber, into which the air is admitted from without the house, by an opening through the wall, and which is discharged into the apartment by lateral openings, after being heated by contact with the fire-place. The smoke, being carried off by a circuitous flue, which passes upwards to the top of the fire-place, and then descends to the floor, also parts with much of its heat before it escapes by the main chimney.

The *Rumford fire-place* is a common fire-place, constructed with a narrow throat to the chimney, for the purpose of diminishing the current of air, an advanced back to throw the fire farther forward, and oblique sides (at an angle of about 135 degrees with the back), which radiate the heat more completely into the room.

The *double fire-place* is an ingenious modification of a Franklin stove. It is formed by setting a small stone fire-place into the chimney, leaving an air chamber, as in the Franklin stove, behind and beneath it, which communicates with the external air, and opens into the apartment. This fire-place is so constructed, as to unite the advantages of the Rumford fire-place with those of a Franklin stove. The air to be heated should be taken from without the house; for if taken from an entry or cellar, the temperature of those places would be very much reduced. The air chamber should be from four to seven inches in diameter, as more heat will be conducted from the stone, and a great quantity of air moderately heated is better than a small quantity made very hot, which is apt to render the air of the apartment disagreeable. (See GRATE, STOVE, and FURNACE.)

FIRE-SHIPS are generally old vessels filled with combustibles fitted with grappling-irons, to hook enemies' ships and set them on fire. The following is a description of the fire-ships which were of such essential service to the Greeks in their late struggle with Turkey: "The vessels usually employed for this service," says Mr. Emerson, "are old ships purchased by the government.

"Their construction, as fire-ships, is very simple; nothing more being wanted than active combustion. For this purpose the ribs, hold, and sides of the vessel, after being well tarred, are lined with dried furze, dipped in pitch and lees of oil, and sprinkled with sulphur; a number of hatchways are then cut along the deck, and under each is placed a small barrel of gunpowder; so that at the moment of conflagration, each throws off its respective hatch, and, giving ample vent to the flames, prevents the deck being too soon destroyed by the explosion. A train which passes through every part of the ship, and communicates with every barrel, running round the deck, and passing out at the steerage window, completes the preparation below; whilst above, every rope and yard is well covered with tar, so as speedily to convey the flames to the sails; and at the extremity of each yardarm is attached a wickered hook, which, being once entangled with the enemy's rigging, renders escape, after coming in contact, almost a matter of impossibility.

The train, to prevent accidents, is never laid till the moment of using it; when, all being placed in order, and the wind favourable, with every possible sail set, so as to increase the flames, she bears down upon the enemy's line, whilst the crew, usually twenty-five or thirty in number, have no other defence than crouching behind the after bulwarks. When close upon the destined ship, all hands descend by the stern into a launch fitted out for the purpose, with high gunwales and a pair of small swivels; and at the moment of contact, the train is fired by the captain, and every hatch being thrown off, the flames burst

forth at the same instant from stem to stern; and, ascending by the tarred ropes and sails, soon communicate with the rigging of the enemy's vessel, who have never yet in one instance been able to extricate themselves. In fact, such was the terror with which they inspired the Turks, that they seldom made the slightest resistance. On the distant approach of the fire-ship, they maintain for some moments, an incessant random cannonade; but at length, long before she comes in contact, precipitate themselves into the sea, and attempt to reach the other vessels, scarcely one remaining to the last moment to attempt to save the devoted ship.

"Sometimes, however, armed boats are sent off from the other vessels of the fleet; but they have never yet been able, either to prevent the approach of the fire-ship, or seize on the crew whilst making their escape; and, though fire-ships are in other countries considered a forlorn hope, such is the stupidity and terror of the Turks, that it is rarely that one of the brulottiers is wounded, and very seldom indeed that any lose their lives. The service, however, from the risk to which it is exposed, is rewarded with higher pay than the ordinary seamen; and, on every occasion of their success, each brulottier receives an additional premium of 100 or 150 piasters."

Fire-Works. See Pyrotechny.

Firkin, in *commerce;* a measure containing eight gallons of ale, and nine of beer.

Firlot, in *commerce;* a dry measure used in Scotland.

Firmament, in the Ptolemaic astronomy; the eighth heaven or sphere, with respect to the seven spheres of the planets which it surrounds. It is supposed to have two motions, a diurnal motion, given to it by the *primum mobile,* from east to west, about the poles of the ecliptic; and another opposite motion, from west to east, which last it finishes, according to Tycho, in 25,412 years; according to Ptolemy, in 36,000; and according to Copernicus, in 25,800; in which time the fixed stars return to the same points in which they were at the beginning. This period is commonly called the *Platonic year,* or the *great year.*

Fishery; a place where great numbers of fish are caught. The principal fisheries for salmon, herring, mackarel, pilchards, &c., are along the coast of England, Scotland, and Ireland; for cod, on the banks of Newfoundland; for whales, about Greenland; and for pearls, in the East and West Indies.

Fishery denotes also the commerce of fish, more particularly the catching them for sale. Were we to enter into a very minute and particular consideration of fisheries, as at present established in this kingdom, this article would swell beyond its proper bounds; because to do justice to a subject of that concernment to the British nation, requires a very ample and distinct discussion. We shall, however, observe, that since the coasts of Great Britain and Ireland abound with the most valuable fish; and since fisheries, if successful, become permanent nurseries for rearing expert seamen; it is a duty we owe to our country, for its natural security, to extend this trade to the utmost. No nation can have a navy, where there is not a fund of business to breed and employ seamen, without any expense to the public, and no trade is so well calculated for training up these useful members of society, as fisheries.

The situation of the British coast is the most advantageous for catching fish in the world; the Scottish islands, particularly those to the north and west, lie most commodious for carrying on the fishing trade to perfection: for no country in Europe can pretend to compete with Scotland in the abundant supply of the finest fish, with which its various creeks, bays, rivers, lakes, and coasts are replenished. King Charles I. was so sensible of the great advantage to be derived from fisheries, that he began the experiment, together with a company of merchants; but the civil war soon occasioned that project to be set aside. King Charles II. made a like attempt, but his pressing wants made him withdraw what money he had employed in the establishment of the fisheries, and the merchants that joined with him did the same. Since the Union, several attempts have been made to retrieve the fisheries, and a corporation was formed for that purpose, entitled the Royal British Fishery.

In the year 1750, the Parliament of Great Britain taking the state of the fisheries into consideration, an act was passed for the encouragement of the white herring fishery, also granting a charter, whereby a corporation was created, to continue 21 years, by the name of the Society of the Free British Fishery, to be under the direction of a governor, president, vice-president, council, &c., who were to continue in office the space of three years, with power to make by-laws, &c., and to raise a capital of 500,000*l.* by way of subscription. And "any number of persons, who, in any part of Great Britain, shall subscribe 10,000*l.* into the stock of this society, under the name of the Fishing Chamber, and carry on the said fishery on their own account of profit and loss, shall be entitled to the same bounty allowed to the society." The bounty is 30*s.* the tun, to be paid yearly, for fourteen years, besides three per cent. for the money advanced by each chamber. The act contains other proper regulations relative to the nets, marks on the herring-barrels, number of hands, the quantity of salt that is entitled to the bounty, &c. It is then by the encouragement originally given by this act, that we see a laudable emulation prevailing all over the kingdom, and fishing vessels fitted out from almost every part, in order to repair to the Shetland Islands, where the herring fishery is carried on with an ardour becoming so important a branch of trade. Scotland, which suffered incredibly from the neglect of this valuable and natural produce of the seas, has not been backward to join in a scheme that tends so evidently to its own advantage; for the cities of Edinburgh and Glasgow, the towns of Montrose, Dundee, Perth, Inverness, and some other boroughs, have raised the proper sum, and chambers have been erected in each of them; the gentlemen of landed property adjoining to the respective places above mentioned, liberally contributing with the merchants towards the prosecution of an undertaking so visibly tending to the good of their country in general.

Fishery, cod. There are two kinds of cod fish, the one green or white cod, the other dried or cured cod, though it is all the same fish differently prepared; the former being sometimes salted and barrelled, then taken out for use; and the latter having laid some considerable time in salt, dried in the sun or smoke. We shall therefore speak of each of these separately.

Fishery, green cod. The chief fisheries for green

cod are in the bay of Canada, on the great bank of Newfoundland, and on the Isle of St. Peter, and the Isle of Sabel, to which places vessels resort from different parts, both of Europe and America. They are from 100 to 150 tons burthen, and will catch between thirty and forty thousand cod each. The most essential part of the fishery, is to have a master who is skilful in cutting up the fish, and above all a good salter, on which the preserving them, and consequently the success of the voyage, depends. The best season is from the beginning of February to the end of April; the fish, which in the winter retire to the deepest water, coming then on the banks, and are then easily taken. What are caught from March to June keep well, but those taken in July, August, and September, when it is warm on the banks, are apt to spoil soon. Every fisher takes but one at a time; the most expert will take from 350 to 400 in a day, but that is the most, the weight of the fish, and the great coldness of the air, on the bank very much fatiguing the men. As soon as the cod are caught, the head is taken off; they are opened, and the intestines withdrawn; the salter then stows them in the bottom of the hold, head to tail, in beds; laying layers of salt and fish alternately, but never mixing fish caught on different days. When they have lain thus three or four days to drain off the water, they are replaced in another part of the ship, and salted again; where they remain till the vessel is loaded. Sometimes they are cut in thick pieces, and put up in barrels for the convenience of carriage.

Fishery, dry cod. The principal fishery for dry cod is from Cape Rose to the Bay des Exports, along the coast of Placentia, there being many convenient inlets or small ports for the fish to be dried in. These, though of the same kind with the fresh cod, are much smaller, and therefore fitter to keep, as the salt penetrates more easily into them. The fishery of both is much alike, only this latter is more expensive, as it takes up more time, and employs more hands, and yet scarce half as much salt is spent in this as in the other. The bait is herrings, of which great quantities are taken on the coast of Placentia. When several vessels meet, and intend to fish in the same part, he whose shallop first touches ground, becomes entitled to the quality and privileges of admiral; he has the choice of his station, and the refusal of all the wood on the coast at his arrival. As fast as the masters arrive, they unrig all their vessels, leaving nothing but the shrouds to sustain the masts, and in the mean time the mates provide a tent on shore, covered with branches of trees, and sails over them, with a scaffold of great trunks of pines, twelve, fifteen, sixteen, and often twenty feet high, commonly from forty to sixty feet long, and about one-third as much in breadth. While the scaffold is preparing, the crew are fishing, and as fast as they catch they bring their fish on shore; open and salt them upon moveable benches, but the main salting is performed on the scaffold. When the fish have taken salt, they wash and hang them to drain on rails; when drained, they are laid on stages, which are small pieces of wood laid across, and covered with branches of trees, having the leaves stripped off for the passage of the air. On these stages they are disposed, head against tail, with the back uppermost, and are turned carefully four times every twenty-four hours. When they begin to dry, they are laid in heaps ten or twelve thick, in order to retain their warmth; and every day the heaps are enlarged, till they become double their original bulk; when two heaps are joined together, which they turn every day as before; lastly, they are salted again, beginning with those first salted, and being laid in huge piles, they remain in that situation till they are carried on board the ship, where they are laid on the branches of trees disposed for that purpose, upon the ballast, and round the ship, with mats to prevent their contracting any moisture. There are four distinct articles of commerce drawn from cod, viz., the zounds, the tongues, the roes, and the oil extracted from the liver. The first is salted at the fishery, together with the fish, and put up in barrels of from 600 to 700 lbs. The tongues are prepared in a similar manner, and brought in barrels containing from 400 to 500 lbs. The roes are also salted in barrels, and serve to cast into the sea to draw fish together, and particularly pilchards. The oil comes in barrels of from 400 to 520 lbs. and is used in dressing leather. The Scotch catch a small kind of cod on the coast of Buchan, and all along the Murray Firth on both sides; as also in the Firth of Forth, Clyde, &c., which is much esteemed. They salt and dry them in the sun upon rocks, and sometimes in the chimney. They also cure skait, and other smaller fish in the same manner, but most of these are for home consumption.

Fishery, herring. Herrings are chiefly found in the North Sea. They are a fish of passage, and commonly go in shoals, being very fond of following fire or light. About the beginning of June, an incredible shoal of herrings, probably much larger than the land of Great Britian and Ireland, come from the north on the surface of the sea; their approach is known by the hovering of sea-fowl in expectation of prey, and by the smoothness of the water; but where they breed, or what particular place they come from, cannot be easily discovered. As this great shoal passes between the shores of Greenland and the North Cape, it is probably confined, and as it reaches the shores of Great Britain, is necessarily divided into two parts. For we find one part of the herrings steering west, or south-west, and leaving the islands of Shetland and Orkney to the left, pass on towards Ireland, where being interrupted a second time, some keeping the shore of Britain, pass away south, down St. George's Channel; while the other part, edging off to the south-west, coast the Western Ocean, till they reach the south shore of Ireland, and then steering south-east, join the rest in St. George's Channel. The other part of the first division made in the north, parting a little to the east and south-east, pass by Shetland, and then make the point of Buchanness, and the coast of Aberdeen, filling as they go all the bays, firths, creeks, &c., with their innumerable multitudes. Hence they proceed forward, pass by Dunbar, and rounding the high shores of St. Abb's Head and Berwick, are seen again off Scarborough; and even then not diminished in bulk, till they come to Yarmouth Roads, and from thence to the mouth of the Thames, after which, passing down the British Channel, they seem to be lost in the Western Ocean.

The vast advantage of this fishery to this country is obvious, when we consider that, though herrings are found upon the shores of North America, they are never seen there in such quantities as with us, and that they are not to be met with in considerable numbers in any of the southern kingdoms of Europe,

as Spain, Portugal, or the southern parts of France; on the side of the ocean, or in the Mediterranean, or on the coast of Africa. There are two seasons for fishing herring, the first from June to the end of August, and the second in autumn, when the fogs become very favourable to this kind of fishing. There is nothing particular in the manner of fishing. The nets in which the fish are drawn should regularly have their meshes an inch square, to let all the lesser fry go through.

The commerce in herrings, white or pickled, and red, is very considerable. The white Dutch herrings are the most esteemed, being distinguished into four sorts, according to their sizes; and the best are those that are fat, fleshy, firm, and white, salted the same day they are taken with good salt, and well barrelled. The British herrings are little inferior, if not equal to the Dutch; for, in spite of all their endeavours to conceal the secret, their method of curing, "lasting," or casking the herrings, is now well known.

Fishery, mackarel. The mackarel are found in large shoals in the ocean, but especially on the French and English coasts. They enter the English channel in April, and proceeding as the summer advances, about June they are on the coast of Cornwall, Sussex, Normandy, Picardy, &c., where the fishery is most considerable. They are taken either with a line or nets: the latter is preferable, and is usually performed in the night time. They are pickled two ways, first by opening and gutting them, and cramming their bellies as hard as possible with salt, by means of a stick, and then laying them in rows at the bottom of the vessel, strewing salt between each layer. The second way is putting them directly into tubs full of brine, made of salt and fresh water, and leaving them to steep till they have taken salt enough to keep. After this, they are barrelled up and pressed close down.

Fishery, pilchard. The chief pilchard fisheries are along the coasts of Dalmatia, on the coast of Bretagne, and along the coasts of Cornwall and Devonshire. That of Dalmatia is very plentiful; that on the coast of Bretagne employs about 300 ships. The pilchards caught on our coasts, though larger, are not so much valued as those on the coast of France, owing principally to their not being so thoroughly cured. They naturally follow the light, which contributes much to the facility of the fishery; the season is from June to September. On the coasts of France they make use of the roes of cod fish, as a bait, which, thrown into the sea, makes them rise from the bottom and run into the nets; on our coasts there are persons posted ashore, who, ascertaining by the colour of the water where the shoals are, make signs to the boats to go among them to cast their nets. When taken, they are brought on shore to a warehouse, where they are laid up in broad piles supported with backs and sides, and as they are piled they salt them with bay salt, in which lying to soak twenty or thirty days, they run out a deal of blood, with dirty pickle and bittern; then they wash them clean in salt-water, and, when dry, barrel and press them hard down to squeeze out the oil, which issues out of a hole in the bottom of the cask. The Cornishmen observe of the pilchard, that it is the least fish in size, most in number and greatest for gain, of any they take out of the sea.

Fishery, salmon. The chief salmon fisheries in Europe are in England, Scotland, and Ireland, in the rivers and sea-coasts adjoining to the mouths of rivers Those most distinguished for salmon in Scotland, are the river Tweed, the Clyde, the Tay, the Dee, the Don, the Spey, the Ness, the Bewley, &c. The chief rivers in England for salmon are the Tyne, the Trent, the Severn, and the Thames. The fishing is not allowed to commence in Scotland before the first of February, and it must be closed by the fourteenth of September. The fishing is performed with nets, and sometimes with movable locks or wears made on purpose, which in certain places have iron or wooden grates so disposed, in an angle, that, being impelled by any force in a contrary direction to the course of of the river, they may give way and open a little at the point of contact, and immediately shut again, closing the angle. The salmon therefore, coming up into the rivers, are admitted into these gates, which open, and suffer them to pass through, but shut again and prevent their return. Salmon are also caught with a spear, which they dart into the fish when they see him swimming near the surface of the water. It is customary likewise, to catch them with a candle and lanthorn, or wisp of straw set on fire; for the fish naturally following the light, are struck with the spear, or taken in a net prepared for that purpose, and lifted with a sudden jerk from the bottom. We make no mention of the method of catching salmon with a line or hook, because it is much the same with trout fishing.

Curing salmon. When the salmon are taken, they open them along, take out the intestines, &c., and cut out the greatest part of the bones, endeavouring to make the inside as smooth as possible, then salt the fish in large tubs for the purpose, where they remain a considerable time soaking in brine, and about October they are packed close in barrels, and sent to London, or exported up the Mediterranean. They have also in Scotland a great deal of salmon salted in the common way, which, after soaking in brine a competent time, is well pressed, and then dried in smoke: this is called kipper, and is chiefly made for home consumption, and, if properly cured and prepared, is reckoned very delicious.

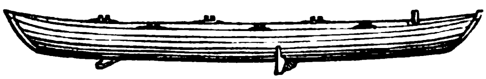
Fishery, sturgeon. The greatest sturgeon fishery is in the mouth of the Volga, on the Caspian Sea, where the Russians employ a great number of hands, and catch them in a kind of inclosure, formed by huge stakes, representing the letter Z, repeated several times. These fisheries are open on the side next the sea, and close on the other, by which means the fish ascending up the river are embarrassed in these narrow angular retreats, and thus are easily killed with a harpoon. Sturgeons, when fresh, eat deliciously; and, in order to make them keep, they are salted or pickled in large pieces, and put up in kegs containing from 30 to 50 pounds. But the great object of this fishery is the roe, of which the Russians are extremely fond, and of which is made the cavia or kavia, so much esteemed by the Italians.

Fishery, whale. Whales are chiefly caught in the North Sea: the largest sort are found about Greenland, or Spitzbergen. At the first discovery of this country, whales not being used to be disturbed, frequently came into the very bays, and were accordingly killed almost close to the shore, so that the blubber being cut off, was immediately boiled into oil on the spot. The ships, in those times, took in nothing but the pure oil and fins, and all the business was executed in the country, by which means, a ship could bring home the product of many more whales

than she can according to the present mode of conducting this trade. The fishery also was then so plentiful, that they were obliged sometimes to send other ships to fetch off the oil they had made, the quantity being more than the fishing ships could bring away. But time and change of circumstances have shifted the situation of this trade. The ships coming in such numbers from Holland, Denmark, Hamburgh, and other northern countries, all intruders upon the English, who were the first discoverers of Greenland, disturbed the whales, and gradually, as other fish often do, forsaking the place, were not to be killed so near the shore as before; but are now generally found in the openings and spaces among the ice, where they have deep water, and where they go sometimes a great many leagues from the shore.

The whale fishery begins in May, and continues all June and July; but, whether the ships have good or bad success, they must come away and get clear of the ice about the close of August, so that in the month of September they may be expected home; but a ship that meets with a fortunate and early fishery in May, may return in June or July.

The manner of taking whales at present is as follows: as soon as the fishermen hear the whale blow, they cry out Fall! fall! and every ship gets out its boat, in each of which there are six or seven men. These boats are peculiarly formed, combining speed with great steadiness. We give an engraving of one employed in the South Seas.



They row till they come pretty near the whale, when the harpooner strikes it with his harpoon. This requires great dexterity, for through the bone of the head there is no striking, but near his snout there is a soft piece of flesh, into which the iron sinks with ease. As soon as he is struck they take care to give him rope enough, otherwise when he goes down, which he frequently does, he would inevitably sink the boat: this rope he draws with such violence, that if it were not well watered, it would, by its friction against the sides of the boat, be soon set on fire. The line fastened to the harpoon is many fathoms long, and is called the fore-runner: it is made of the finest and softest hemp, that it may slip the easier; to this they join a heap of lines of 90 or 100 fathoms each, and when there are not enough in one long boat, they borrow from another. The man at the helm observes which way the rope goes, and steers the boat accordingly, that it may run exactly out before; for the whales run away with the line with such rapidity, that it would overset the boat if it were not kept straight. When the whale is struck, another long boat rows before and observes which way the line stands, and sometimes pull it; if they feel it stiff, it is a sign the whale still pulls in strength, but if it hangs loose, and the boat lies equally high behind and before upon the water, they pull it in gently, but take care to coil it so that the whale may have it again easily if he recovers strength. They are careful, however, not to give him too much line, because he sometimes entangles it about a rock, and pulls out the harpoon. The fat whales do not sink as soon as dead, but the lean ones do, and come up some days afterwards. As long as they see whales they lose no time in cutting up what they have taken, but keep fishing for others; when they see no more, or have taken enough, they begin with taking off the fat in the following manner: the whale being lashed alongside, they lay it on one side, and put two ropes, one at the head, and the other in the place of the tail, which, together with the fins, is struck off as soon as he is taken, to keep those extremities above water. On the off side of the whale are two boats to receive the pieces of fat, utensils, and men, that might otherwise fall into the water on that side. These precautions being taken, three or four men, with irons at their feet to prevent slipping, get on the whale, and begin to cut out pieces of about three feet thick and eight long, which are hauled up at the capstan or windlass. When the fat is all got off, they cut off the whiskers of the upper jaw with an axe. Before they are cut they are all lashed to keep them firm, which also facilitates the cutting, and prevents them from falling into the sea; when on board, five or six of them are bundled together and properly stowed, and after all is got off, the carcase is turned adrift, and devoured by the bears and sharks, who are very fond of it. In proportion as the large pieces of fat are cut off, the rest of the crew are employed in slicing them smaller, and picking out all the lean. When this is prepared, they stow it under the deck, where it lies till the fat of all the whales is on board; then, cutting it still smaller, they put it up in tubs in the hold, squeezing them very close. Nothing now remains but to sail homewards, where the fat is to be boiled and melted down into train oil. In some cases, however, the boiling is done on the spot.

It is unnecessary to speak in this place of the advantages that are derived to Great Britain from the whale fishery.

Besides these fisheries, there are several others both on the coast of Great Britain and in the North Seas, which although not much the subject of merchandize, nevertheless employ great numbers both of ships and men; as 1. The oyster fishery at Colchester, Feversham, the Isle of Wight, in the Swales of the Medway, and in all the creeks between Southampton and Chichester, from whence they are carried to be fed in pits at Wevenloe, and also to many other places.

2. The lobsters are caught along the British Channel, the Firth of Edinburgh, on the coast of Northumberland, and on the coast of Norway, from whence great quantities are brought to London. The fishing for the pot-fish, fin-fish, sea-unicorn, sea-horse, and the seal, or dog-fish, are very valuable to this country; besides which it may be especially noticed, that the horn of the sea-unicorn is as estimable as ivory, and the skins of the seals are particularly useful in various branches of commerce.

Fitchee, in *heraldry*; an epithet for a cross that ends in a sharp point. It is supposed to have taken its rise from the practice of Christians formerly carrying the cross with them wherever they went, which they fixed in the ground as they stopped.

Fixation, in *alchemy*; the making any volatile spirituous body endure the fire, and not fly away either by repeated distillations or sublimations.

Fixed Air; a name formerly applied to carbonic acid gas.

Fixed Oils. There are two species of oil in vegetables, agreeing in the common properties of unctuosity and inflammability, but essentially differ-

ent in many of their chemical qualities. The one being capable of being volatilized without decomposition, is named *volatile oil*, the other is denominated *fixed oil*. The latter is generally contained in the seeds and fruits of vegetables, and varies in its properties, according to the plants by which it is afforded. The fixed oils are extracted by pressure, and accordingly are frequently called *expressed oils*. When the process is aided by heat, the action of which is to render the oil more fluid, the product is esteemed less pure. The purest oils are those expressed from the fruit of the olive, or the seeds of the almond; others, less pure, come from flax-seed and hemp-seed. These oils are usually fluid, but of a somewhat thick consistence, and liable to congeal at very moderate colds; palm-oil is even naturally concrete. When fluid, they are transparent, of a yellow or yellowish green colour, and capable of being rendered quite transparent by the use of animal charcoal. They are inodorous and insipid, at least if they have been obtained with due care; and free from the mucilaginous and extractive matter of the plants from whence they come; are lighter than water, with which they do not unite, and are very sparingly soluble in alcohol, with the exception of castor-oil.

At a temperature below 600° Fahrenheit, they remain unchanged. In the neighbourhood of this temperature, however, they begin to boil, and to disengage an inflammable vapour; but the oil thus condensed is altered in its properties; it loses its mildness, becomes more limpid and volatile, a portion of carbon being likewise deposited. Transmitted through an ignited tube, fixed oil is converted into carbonic acid and carbureted hydrogen, with a small portion of acid liquor, and a residuum of charcoal. In the open air, it burns with a clear white light, and formation of water and carbonic acid gas. Accordingly, the fixed oils are capable of being employed for the purposes of artificial illumination, as well in lamps as for the manufacture of gas. Fixed oils undergo considerable change by exposure to the air. The rancidity which then takes place is occasioned by the mucilaginous matters which they contain becoming acid. From the operation of the same cause, they gradually lose their limpidity, and some of them, which are hence called *drying oils*, become so dry, that they no longer feel unctuous to the touch, nor give a stain to paper. This property, for which linseed-oil is remarkable, may be communicated quickly, by heating the oil in an open vessel. The drying oils are employed for making oil-paint, and, mixed with lamp-black, constitute printers' ink. During the process of drying, oxygen is absorbed in considerable quantity. This absorption of oxygen is, under certain circumstances, so abundant and rapid, and accompanied with such a free disengagement of caloric, that light, porous, combustible materials, such as lamp-black, hemp or cotton-seed may be kindled by it. Many instances of spontaneous combustion have occurred from this cause; and particularly in the Russian arsenals, where, at length, a series of experiments was instituted to ascertain the accompanying circumstances. It appears from these investigations, that if hemp, flax, or linen cloth, steeped in linseed oil, lie in a heap, and be somewhat pressed together and confined, its temperature rises, a smoke issues from it, and, at length, sometimes within twenty four or even twelve hours, it takes fire. The same thing happens with mixtures of oil and fine charcoal, and with lamp-black wrapped up in linen; from whence it is conjectured, that many extensive fires, which have broken out in cotton manufactories, and for which no cause could be assigned, must have arisen from this spontaneous inflammability of oils.

Fixed oils unite with the common metallic oxides. Of these compounds, the most interesting is that with the oxide of lead. When linseed-oil is heated with a small quantity of litharge, a liquid results which is powerfully drying, and is employed as oil varnish. Olive-oil, combined with half its weight of litharge, forms the common *diachylon plaster*. The fixed oils are readily attacked by alkalies. With ammonia, they form a soapy liquid, to which the name of *volatile liniment* is applied. They are oxidated by a number of the acids. Sulphuric acid soon renders them black; the oxygen of the acid attracting part of the hydrogen of the oil, and causing the deposition of charcoal; and if heat is applied, a large portion of sulphurous acid is disengaged, and even sulphur is evolved. Nitric acid renders them thick; if heat is applied, the action is more rapid, and a yellow colour is communicated, the oil being rendered concrete. Chlorine thickens oil, and renders it white. When boiled in sulphur, a compound is formed of a brown colour, a very fetid smell, and acrid taste. It likewise, when heated, dissolves phosphorus, forming a liquid which becomes luminous when exposed to the air. Olive-oil, according to the analysis of Gay-Lussac and Thénard, consists of carbon 77.213, oxygen 9.427, and hydrogen 13.360.

FIXED STARS; those stars which appear to remain always at the same distance from each other, and in the same relative position. The name comprehends, therefore, all the heavenly bodies, with the exception of the planets, with their moons and the comets. But, besides the apparent motion of the fixed stars, resulting from the diurnal rotation of our earth upon its axis, and from the precession of the equinoxes, and the aberration of light, a very slow proper motion has been observed in them, so that it is not strictly true that the fixed stars remain in the same relative position. It has been found that Sirius, for example, has, since the time of Tycho-Brahe, moved about two minutes from its place, &c. But Herschel (On the Proper Motion of the Sun and Solar System, in the *Philosophical Transactions*, vol. 73.) has proved that this apparent change of place results from a real motion of our whole solar system in the celestial spaces. Stars have also been seen to appear suddenly in the heavens, and again to disappear. Of others it has been remarked that their size appears alternately to increase and to diminish. Their distance from our earth is, in the most literal sense of the word, immeasurable. The most powerful telescopes cannot give them a sensible diameter.

We can obtain an idea of their size from the circumstance that, although we approach them by forty millions of miles (the diameter of the earth's orbit), and recede from them as far, we can find no difference in them. Huygens, by comparing the light of Sirius with that of the sum, tried to determine its distance from the earth, and upon the supposition that Sirius is of the same size as the sun, made its distance 27,664 times greater. However conjectural such determinations must be, they entirely succeed in proving to us that the celestial spaces have an extent beyond the power of the human mind to con-

ceive. We are in equal uncertainty with regard to the nature and constitution of the fixed stars; but it is in the highest degree probable that they are luminous worlds or suns, around which, as around our sun, planets revolve in determined paths, receiving from them light and heat.

The fixed stars are divided according to the difference in their brilliancy, which are very visible to the naked eye, into stars of the first, second, third magnitude, &c. But besides these stars, which appear in the heavens as distinct bright points of light, the eye, in the clear winter nights, sees here and there little white clouds. These nebulous spots are groups of innumerable stars, which the telescope reveals to us; and the limited power of our instruments alone prevents us from looking forward without end, into the infinite regions of space.

Much general information is to be found in *Bode's Introduction to a Knowledge of the Starry Heavens*, (19th edition, Berlin, 1823). In order to distinguish more easily the fixed stars from each other, names were given to the most remarkable of them in very ancient times, and they were divided into groups or constellations. Astronomers have given descriptions of all the stars, according to their situations, with their names, magnitude, &c. Cassini, Lalande, Zach, and Piazzi have done so; and great praise is due to J. E. Bode's *Uranographia, sive Astrorum Descriptio, xx tabulis æneis incisa, ex recentissimis et absolutissimis Astrorum Observationibus.*

FLAG; an ensign or colours, a cloth on which are usually painted or wrought certain figures, and borne on a staff;—in the army, a banner by which one regiment is distinguished from another;—in the marine, a certain banner by which an admiral is distinguished at sea from the inferior ships of his squadron; also the colours by which one nation is distinguished from another. In the British navy, flags are either red, white, or blue, and are displayed from the top of the main-mast, fore-mast or mizzen-mast, according to the rank of the admiral. When the flag is displayed at the main-top-gallant-mast head, the officer distinguished thereby is known to be an admiral; when from the fore-top-gallant-mast head, a vice-admiral; and when from the mizzen-top-gallant-mast head, a rear-admiral.

The union is the highest admiral's flag. The next flag after the union is white, at the main; and the last, which characterizes an admiral, is blue, at the same mast-head. For a vice-admiral, the first flag is red, the second white, and the third blue, at the fore-top-gallant-mast head. The same order is observed with regard to rear-admirals, whose flags are displayed at the mizzen-top-gallant-mast head. The lowest flag in this navy is, accordingly, blue at the mizzen.

All the white flags have a red St. George's cross in them, inserted originally, to distinguish them from the old French white flag with a white cross. The French national flag, since the late revolution, is the tri-coloured flag, red, white, and blue. When a council of war is held at sea, if it be on board the admiral, they hang a flag on the main shrouds; if in the vice-admiral, in the fore shrouds; and if in the rear-admiral, in the mizzen shrouds. The flags borne on the mizzen are particularly called *gallants.*

To heave out the flag, is to put out or hang abroad the flag. To hang out the white flag, is to call for quarter; or it shows, when a vessel arrives on a coast, that it has no hostile intention, but comes to trade or the like. To hang out the red flag, is to give a signal of defiance and battle. To lower or strike the flag, is to pull it down upon the cap, or to take it in, out of the respect or submission due from all ships or fleets, to those any way justly their superiors. To lower or strike the flag, in an engagement, is a sign of yielding. The way to lead a ship in triumph is, to tie the flags to the shrouds, or the gallery in the hind-part of the ship, and let them hang down towards the water, and tow the vessel by the stern. Livy relates that this was the way the Romans used the vessels of Carthage. (See STANDARDS.)

FLAGEOLET; a small pipe or flute, the notes of which are exceedingly clear and shrill. It is generally made of box or other hard wood, though sometimes of ivory, and has six holes for the regulation of its sounds, besides those at the bottom and mouth-piece, and that behind the neck.

FLAIL; an instrument for thrashing corn, that consists of—1. the hand-staff, which the labourer holds in his hand; 2. the swiple, or that part which strikes the corn; 3. the caplins, or leathern thongs that bind the hand-staff and swiple; 4. the middle band, being the leathern thong, or fish-skin, that ties the caplins together.

FLAMBEAU; a kind of large taper, made of hempen wicks, by pouring melted wax on their top, and letting it run down to the bottom. This done, lay them to dry, after which roll them on a table, and join four of them together by means of a red-hot iron; and then pour on more wax, till the flambeau is brought to the size required. Flambeaus are of different lengths, and made either of white or yellow wax. They serve to give light in the streets at night, or on occasion of illuminations.

FLAME. Newton and others have considered flame as an ignited vapour, or red-hot smoke. This, in a certain sense, may be true; but, no doubt, it contains an inaccurate comparison. It appears to be well ascertained, that flame always consists of volatile inflammable matter, in the act of combustion, or combination with the oxygen of the atmosphere. Many metallic substances are volatilized by heat, and burn with a flame, by the contact of the air in this rare state. Sulphur, phosphorus, and some other basis of acids, exhibit the same phenomenon. But the flames of organized substances are in general produced by the extrication and ascension of hydrogen gas, with more or less of charcoal.

When the circumstances are not favourable to the perfect combustion of these products, a portion of the coal passes through the luminous current unburned, and forms smoke. Soot is the condensed matter of smoke. As the artificial light of lamps and candles is afforded by the flame they exhibit, it seems a matter of considerable importance to society, to ascertain how the most luminous flame may be produced with the least consumption of combustible matter.

There does not appear to be any danger of error in concluding, that the light emitted will be greatest when the matter is completely consumed in the shortest time. It is therefore necessary that a stream of volatilized combustible matter, of a proper figure, at a very elevated temperature, should pass into the atmosphere with a certain determinate velocity. If the figure of this stream should not be duly proportioned—that is to say, if it be too thick—its in-

ternal parts will not be completely burned, for want of contact with the air. If its temperature be below that of ignition, it will not burn when it comes into the open air. And there is a certain velocity, at which the quantity of atmospherical air which comes in contact with the vapour will be neither too great nor too small; for too much air will diminish the temperature of the stream of combustible matter so much as very considerably to impede the desired effect; and too little will render the combustion languid.

We have an example of a flame too large, in the mouths of the chimneys of furnaces, where the luminous part is merely superficial, or of the thickness of about an inch or two, according to circumstances, and the internal part, though hot, will not set fire to paper passed into it through an iron tube; the same defect of air preventing the combustion of the paper as prevented the interior fluid itself from burning. And in the lamp of Argand, we see the advantage of an internal current of air, which renders the combustion perfect by the application of air on both sides of a thin flame. So likewise a small flame is whiter and more luminous than a larger; and a short snuff of a candle, giving out less combustible matter in proportion to the circumambient air, the quantity of light becomes increased to eight or ten times what a long snuff would have afforded. (See CALORIC and COMBUSTION.)

FLANCH, in *heraldry;* one of the honourable ordinaries formed by an arch line, which begins at the corners of the chiefs and ends in the base of the escutcheon.

FLANK, in *fortification;* that part of a work which affords a lateral defence to another. In a bastion, the flanks are those lines which join the central wall.

In tactics, *flank* signifies the outer extremity of the wing of an army; and it is one of the most common manœuvres to surround this most vulnerable point. The enemy, if proper precautions have not been taken, is then obliged to withdraw his flank; therefore to change his front, and is thus exposed to a defeat. This manœuvre is called *outflanking.* A bold, but not always practicable manœuvre, to prevent the consequences of this attempt, is that of outflanking the enemy who makes it.

FLANNEL; a woollen fabric of great importance in our commerce. Flannel is composed of a woof and warp, and woven after the manner of baise. Various theories have been adopted to prove the utility of flannel as an article of dress: it is unquestionably a bad conductor of heat, and on that account very useful in cold weather; this is accounted for from the structure of the stuff; the fibres touch each other very slightly, so that the heated air moves very slowly through the interstices, which being already filled with air, give little assistance in carrying off the heat. On this subject Count Rumford has made many experiments, from which it should seem, that though linen, from the apparent ease with which it receives dampness from the atmosphere, appears to have a much greater attraction for water than any other, yet that those bodies which receive water in its unelastic form with the greatest ease, or are most easily wet, are not those which in all cases attract the moisture of the atmosphere with the greatest avidity. "Perhaps," says he, "the apparent dampness of linen to the touch arises more from the ease with which that substance parts with the water it contains, than from the quantity of water it actually holds; in the same manner as a body appears hot to the touch in consequence of its parting freely with its heat, while another body, which is really at the same temperature, but which withholds its heat with great obstinacy, affects the sense of feeling much less violently. It is well known that woollen clothes, such as flannels, &c., worn next the skin, greatly promote insensible perspiration. May not this arise principally from the strong attraction which subsists between wool and the watery vapour which is continually issuing from the human body? That it does not depend entirely on the warmth of that covering is clear; for the same degree of warmth produced by wearing more clothing of a different kind does not produce the same effect. The perspiration of the human body being absorbed by a covering of flannel, it is immediately distributed through the whole thickness of that substance, and by that means exposed by a very large surface to be carried off by the atmosphere: and the loss of this watery vapour which the flannel sustains on the one side, by evaporation, being immediately restored from the other, in consequence of the strong attraction between the flannel and this vapour, the pores of the skin are disencumbered, and they are continually surrounded by a dry and salubrious atmosphere." He expresses his surprise, that the custom of wearing flannel next the skin should not have prevailed more universally. He is confident it would prevent a number of diseases; and he thinks there is no greater luxury than the comfortable sensation which arises from wearing it, especially after one is a little accustomed to it. "It is a mistaken notion," says he, "that it is too warm a clothing for summer. I have worn in it the hottest climates, and at all seasons of the year, and never found the least inconvenience from it. It is the warm bath of perspiration confined by a linen shirt, wet with sweat, which renders the summer heats of southern climates so insupportable; but flannel promotes perspiration, and favours its evaporation; and evaporation, as is well known, produces positive cold."

FLASK; a vessel for holding gunpowder, and measuring it out when the piece is to be loaded.

FLASK, or FLASQUE, in *heraldry;* an ordinary which resembles the flanch in form, but is smaller.

FLASQUES, in *gunnery;* the two cheeks of the carriage of a great gun.

FLAX has been cultivated from remote antiquity, throughout a great part of Europe, Asia, and the north of Africa, for various purposes. Its native country is not known with certainty, though, according to Olivier, it is found wild in Persia. This plant is cultivated principally for the fibres yielded by the bark, of which linen cloth is made. The use of this article is so ancient, that no tradition remains of its introduction. The ancient Scandinavians and other barbarous nations were clothed with linen. The mummies of Egypt are enveloped with it, and immense quantities are still made in that country, especially about the mouths of the Nile; and it is worn almost exclusively by the inhabitants. Syria, Barbary, Abyssinia, and other places, are supplied from Egypt. Italy also receives vast quantities from the same country, through the merchants of Constantinople.

The use of linen passed from Egypt into Greece, and afterwards into Italy. Besides forming agree-

able and beautiful apparel, the rags, after being converted into paste, are made into paper. The seeds of the flax are mucilaginous and emollient, and an infusion of them is often used as a drink in various inflammatory disorders: they also yield an oil, which is well known in commerce, and which differs, in some respects, from most expressed oils, as in congealing in water, and not forming a solid soap with fixed alkaline salts. This oil has no remarkable taste, is used for lamps, sometimes in cookery, and also forms the base of all the oily varnish made in imitation of China varnish. It is much employed in the coarser kinds of painting, especially in situations not much exposed to the weather. Equal parts of lime-water and this oil form one of the best applications for burns. The cakes remaining after the oil is expressed, are used for fattening cattle and sheep.

Flax-seed has been substituted for grain in times of scarcity, but it is heavy and unwholesome. In Egypt, flax is sown about the middle of December, and is ripe in March. In Europe and in this country, it is generally sown in the spring, from March to May; sometimes, however, in September and October. In a dry and warm country, it is better to sow in autumn, as the rains of autumn and winter favour its growth, and it acquires strength enough to resist the drought, should there happen to be any in the spring. On the other hand, in cold and moist countries, sowing should be deferred till late in the spring, as too much moisture is hurtful.

A light soil is the most suitable, though good crops are obtained from strong and clayey grounds. As it appears to degenerate when repeatedly sown without changing the seed, it is usual, in some countries, to import the seed from the North of Europe, particularly from Riga, which affords the best. The American seed, also, bears a high reputation, and, in Ireland, is preferred for the lighter soils, and the Baltic for the more clayey. In general, however, in order to prevent its degenerating, it is sufficient to change the soil frequently, by sowing in the heavier lands the seed ripened in the lighter, and the reverse.

There are three varieties of flax: the first produces a tall and slender stem, with very few flowers, ripens late, and affords the longest and finest fibres; the second produces numerous flowers, and is the most proper for cultivation, where the seed is the object; but its fibres are short and coarse; the third is the most common, and is intermediate between the other two. It is important not to mix the seeds of these three varieties, as they ripen at different periods, and, besides, the first should be sown more closely, and the second at greater intervals than the third.

When it is a few inches high, it should be freed from weeds, particularly from the cuscuta, a parasitical plant, consisting of yellowish or reddish filaments, and small white flowers: all the stems which have this plant attached to them should be pulled up and burnt. To prevent its lying on the ground, it is usual, with some, to stretch lines across the field, intersecting each other, and fastened at the intersections. As soon as it begins to turn yellow, and the leaves are falling, it is pulled, tied together in little bundles, and usually left upright on the field till it becomes dry, when the seeds are separated, either by beating on a cloth, or by passing the stems through an iron comb. The stems, after being placed even at the base, are again tied together in bundles for rotting—a process which is necessary to facilitate the separation of the fibres, and which is accomplished in three different manners: 1st. on the earth, which requires a month or six weeks; 2nd. in stagnant waters, which is the most expeditious manner, as only ten days are necessary; but the fibres are of inferior quality; 3rd. in running water, for which about a month is necessary. The finest fibres are produced by this latter mode, and certain rivers are considered as possessing advantages over others. Whatever method be made use of, it is necessary to turn it every three or four days. After this process, it is taken out, dried, and is ready for obtaining the fibres. For this purpose, a handful is taken in one hand, laid upon a table, and beaten with a wooden instrument, afterwards drawn forcibly over the angle of the table with both hands, in order to free it from fragments of the stem. Another method is by machinery. It is afterwards heckled or combed with a sort of iron comb, beginning with the coarser and ending with the finer, and is now ready for spinning.

Mr. Bundy has taken out a patent for breaking and dressing flax and hemp. He constructs a frame carrying three fluted or indented rollers, formed as the frustrums of cones, about seven inches long in the working part, three inches and a half in diameter at the larger end, and two inches at the smaller.

Two of these rollers are placed in proper carriages at the bottom, and the third above, lying upon the two lower ones, but not in immediate contact with them. Springs are so placed as, when occasion requires, to raise the upper roller for the introduction of the flax. A treadle readily enables the operator to bring the rollers in contact, and carry on the process. This operation is continued until all the woody parts become broken and separated from the fibre. When it is intended that the flax should be bleached before it is spun, the patentee adopts the following process:—He constructs trays, in which he places small parcels of the flax, and, after leaving them in cold soft water for a few days, the vegetable is freed of its gluten and colouring matter, when it is to be worked in the machine as already described.

If it is required to be still softer, for spinning into yarn of the best quality, it should be boiled in soap and water, well agitated, and then carefully removed and dried.

Flax, New Zealand. The fibres of this plant are used, by the inhabitants of New Zealand, for cords and clothing, instead of hemp and flax, to which they are much superior. They are, in fact, stronger than any other known vegetable fibres, hardly yielding, in this respect, to silk. The stem of this plant grows six feet high and upwards, is straight, very firm, and is branched or paniculate above, and sheathed at base by the leaves; the leaves are five or six feet long, ensiform, very much compressed at base, where they are disposed on two opposite sides of the stem, and somewhat resemble those of the common cat-tail; the flowers have six petals, six stamens, and one style. In its native country, it grows in both wet and dry places, and is apparently adapted to every kind of soil, but seems to prefer marshy places. The fibres are very long, of a snowy whiteness, and possess the lustre of silk. French enterprize has been awakened to the importance of

introducing the culture of this plant. It bears the climate of the south of France, and has remained in the open air throughout the year. It has succeeded perfectly in Normandy, producing seeds which have been sown, and proved fertile. Every year, as the inner leaves shoot upwards, it loses the outer; and, consequently, the outer leaves should be pulled off when they have acquired their full growth, while the stock may remain in the ground for years. It may be multiplied by off-sets which are separated in the spring. The method by which the New Zealanders obtain the fibres is very tedious; accordingly, the French agriculturists have devised other modes, which promise success.

FLEAM, in *surgery;* an instrument for lancing the gums. Farriers employ an instrument of this name for bleeding horses.

FLEECE, ORDER OF THE GOLDEN, one of the oldest and most honourable orders in Europe, was established by Philip III. of Burgundy, surnamed the Good, January 10, 1430, at Bruges, on the occasion of his marriage with his third wife, Isabella, daughter of King John I. of Portugal. In the beginning of the statutes of the order (1431), Philip says, he took the name from the golden fleece of the Argonaut Jason, and that the protection of the church was the object of the order. He declared himself grand-master, and ordered that this dignity should be hereditary in his successors in the government. The decoration of the order is a chain, composed of flints and steels, alternately; in the middle of which the golden fleece is fastened. Annual chapters were to be held, when the majority was to decide on the admission of new members. But several of the first statutes were changed. Philip himself increased the number of knights from 24 to 31; Charles V. his grandson, to 51. The last chapter was held in 1559, at Ghent. Since that time, the monarch has made knights of the golden fleece according to his pleasure. When, after the death of Charles V. the Burgundian possessions and the Netherlands fell to the Burgundian-Spanish line of the house of Austria, the kings of Spain exercised the office of grand-master of the order; but when Charles III. (Charles VI. in the line of German emperors) received, after the war of the Spanish succession, the Spanish, afterwards the Austrian, Netherlands, he insisted upon being the grand-master of the order. The dispute was not settled, and the order, at present, is conferred both at Vienna and Madrid. The chain is now only the decoration of the grand-master; the other knights wear a golden fleece on a red ribbon. The Spanish golden fleece differs from the Austrian by the inscription *Pretium laborum, non vitæ*, upon the steel. At both courts, the order of the golden fleece is the highest; and, as its nominal object is the protection of religion, it is conferred only on Catholics, Protestant sovereigns making the only exception.

FLEECES, THE ORDER OF THE THREE GOLDEN. August 15th 1809, in the camp at Schönbrunn, Napoleon added a third order to those of the Legion of Honour and of the Iron Crown. It was intended to consist of 100 grand officers, 400 commanders, and 1000 other members, chiefly military men. No civilians, except the grand dignitaries of the empire, ministers who had held their offices ten years, ministers of state after twenty years' service, and presidents of state after three years' service, were to be admitted. Of the military, only those who had received three wounds, in three different battles, were to be admitted. Those regiments which had been present in the great battles of the grand army were to receive this order instead of their eagles; their most meritorious subaltern officers were named commanders, and the most meritorious non-commissioned officer or private of each battalion was to be made a member; the former with an income of 4000 francs, the latter with one of 1000, from the funds of the order. To become a grand officer, it was necessary to have commanded a division of the grand army, in the field or at a siege. The emperor was to be grand-master; the King of Rome was the only hereditary member; the princes of the blood could not be admitted into the order, unless they had served in one campaign, or been at least two years in the army. It is not known what induced the emperor to drop this scheme. The only appointments that were made were those of Count Andreossi, chancellor of the order, and Count Schimmelpenninck, treasurer.

FLEET, in *naval affairs;* a number of ships together in company, or under one commander.

FLESH; the muscles of animals. These consist chiefly of fibrin, with albumen, gelatin, extractive matter, phosphate of soda, phosphate of ammonia, phosphate and carbonate of lime, and sulphate of potash.

FLEXOR, in *anatomy;* an epithet for several muscles whose office it is to bend the parts into which they are inserted, as *flexor carpi radialis*, a muscle of the wrist; *flexor tertii internodii*, a muscle of the thumb; *flexor pollicis brevis*, a muscle of the great toe, &c.

FLINT; a mineral which occurs of all colours, but generally yellowish and dark gray, commonly in a compact amorphous body, rarely crystallized. It is widely spread throughout the earth, in primitive, secondary, and alluvial formations, but especially in limestone. Its principal use is for gun-flints, and it is also reduced to a powder and used in the manufacture of porcelain and glass. This important application of silex will be fully discussed under the latter article. The manufacture of gun-flints is exceedingly simple, and a good workman will make 1000 flints a day. The whole art consists in striking the stone repeatedly with a kind of mallet, and bringing off, at each stroke, a splinter sharp at one end and thicker at the other. The splinters are afterwards shaped at pleasure, by laying the line at which it is wished they should break upon a sharp instrument, and then giving it small blows with a mallet. Large manufactures of gun-flints exist at Muesnes in Berry, in Galicia, and at Avio in the Tyrol. (See MINERALOGY.)

FLOAT-BOARDS, in *mechanics;* boards fixed to the water-wheels of undershot mills, serving to receive the impulse of the stream.

FLOATING BREAKWATER. This marine contrivance may consist of a series of square frames of timber, connected by mooring-chains, or cables attached to anchors, or blocks of marble. The frame-work may be made of logs of yellow pine, from 30 to 50 feet long and from 18 to 20 inches square, bolted together very firmly, and increased in height as the situation may be boisterous, in order to break the violence of the agitated waves, and allow the vessels riding within these quadrangular basins more safety and protection. Such *breakwaters* are admirably adapted to bathing-places and swimming stations, since they

will always produce smooth water, and protect the machines.

Floating Bridge; a bridge made in the form of a redoubt, consisting of two boats covered with planks.

Floating Light; a hollow vessel of tinned iron plate, made in the form of a boat, with a reflector or lantern, for the purpose of saving those who may have the misfortune to fall overboard in the night.

Flood-Gate; a gate or sluice which may be opened or shut at pleasure for the admission or exclusion of the water.

Flood-Mark; the mark which the sea makes on the shore at the highest tide, otherwise called *high-water-mark*.

Floor Timbers are those parts of the ship's timbers which are placed immediately across the keel, and upon which the bottom of the ship is framed; to these the upper parts of the timbers are united, being only a continuation of floor timbers upwards.

Florentine Work; a kind of mosaic work, consisting of precious stones and pieces of marble. The Florentines were distinguished for this kind of work—hence the name.

Florin is sometimes used for a coin, and sometimes for a money of account. The florin coin is of different values. The gold florins are, most of them of a coarse alloy, some of them not exceeding thirteen or fourteen carats, and none of them seventeen and a half. As to silver florins, those of Holland are worth about 1*s.* 8*d.*

Flourish; an appellation sometimes given to the decorative notes which a singer or instrumental performer adds to a passage, with the double view of heightening the effect of the composition, and of displaying his own flexibilty of voice or finger. There is nothing of which a sensible performer will be more cautious than of the introduction of *flourishes*, because he is never so much in danger of mistaking, as when he attempts to improve his author's ideas. With performers of little taste, plain passages are indiscriminate invitations to ornament; and too frequently in the *flourish*, the beauty of a studied simplicity is at once overlooked and destroyed. Auditors who are fonder of execution than of expression, and more alive to flutter than to sentiment, applaud these sacrifices to vanity; but those who prefer nature to affectation, and listen in order to *feel*, know exactly how to value such performers.

Flower de Lis, or Flower de Luce, in *heraldry;* a bearing representing the lily, called the *queen of flowers*, and the *true hieroglyphic of royal majesty;* but of late it is become more common, being borne in some coats one, in others three, in others five, and in some *semée*, or spread all over the escutcheon in great numbers.

Flowers, in *chemistry;* a term formerly applied to a variety of substances procured by sublimation, in the form of slightly cohering powder: hence, in all old books, we find mention made of the flowers of antimony, arsenic, zinc, and bismuth, which are the sublimed oxides of these metals, either pure or combined with a small quantity of sulphur: we have also still in use, though not generally, the terms *flowers* of sulphur, benzoin, &c.

Flower Trade in Holland. Haarlem was formerly the centre of this trade. In 1636 and 1637, a real tulip mania prevailed in Holland. Bulbs, which the seller did not possess, were sold at enormous prices, on condition that they should be delivered to the purchaser at a given time. 13,000 florins were paid for a single Semper Augustus; for three of them together, 30,000 fl.; for 148 grains weight, 4500 fl.; for 296 grains of Admiral Liefkenshoek, more than 4000 fl.; for Admiral Enkhuizen, more than 5000, &c. For a Viceroy, on one occasion, was paid 4 tons of wheat, 8 tons of rye, 4 fat oxen, 8 pigs, 12 sheep, 2 hhds. of wine, 4 bbls. of beer, 2 bbls. of butter, 1000 lbs. of cheese, a bundle of clothes, and a silver pitcher. At an auction in Alcmaer, some bulbs were sold for more than 90,000 fl. An individual in Amsterdam gained more than 68,000 florins, by this trade, in four months. In one city of Holland, it is said, more than 10,000,000 tulip bulbs were sold. But when, on account of the purchasers refusing to pay the sums agreed upon, the States General (April 27, 1637) ordered that such sums should be exacted, like other debts, in the common way, the extravagant prices fell at once, and a Semper Augustus could be had for 50 florins: yet the profits of raising rare tulips were afterwards considerable; and, even at present, we find 25 to 150 fl. the price of a single rare tulip, in the catalogues of the Haarlem florists.

Until the time of the French revolution, the florists of Haarlem obtained their bulbs principally from Lisle, and other towns in Flanders, where the clergy were engaged in raising them. They afterwards carried on the business themselves; but the whole trade is now of little importance. Even after the decline of this trade, Alcmaer did not lose its reputation for possessing the first amateurs and connoisseurs in flowers. Persons in independent circumstances engaged in cultivating flowers, particularly hyacinths. Florists obtain their supplies, not only of hyacinths, but also of ranunculuses, auriculas, pinks, anemonies, &c., the demand for which has been gradually increasing, partly from that source, and partly from foreign countries. Haarlem still continues to be the emporium for the most beautiful of these articles.—Hyacinths first began to rise in estimation in 1730. In that year, 1850 fl. were paid for passe-non-plus-ultra, and in the same proportion for others. Between Alcmaer and Leyden there are more than 20 acres of land appropriated to hyacinths alone, which thrive best in a loose and sandy soil. There are still 12 or 13 great florists in and around Haarlem, besides a number of less importance. They send their flowers to Germany, Russia, England, &c., and even to Turkey and the Cape of Good Hope.

Flowing; the position of the sheets or lower corners of the principal sails, when they are loosened to the wind, so as to receive it more nearly perpendicular than when they are close-hauled, although more obliquely than when going before the wind. A ship is, therefore, said to have a flowing sheet, when the wind crosses the line of her course nearly at right angles; that is to say, a ship steering due north, with the wind at the east, or directly on her side, will have a flowing sheet; whereas, if the sheets were extended close aft, she would sail two points nearer the wind, viz., N. N. E.

Fluates, in *chemistry;* salts first discovered by Scheele, and distinguished by the following properties: When sulphuric acid is poured upon them, they emit acrid vapours of fluoric acid, which corrode glass. When heated, several of them phosphoresce. They are not decomposed by heat, nor altered by combustibles. They combine with silica by means

of heat. Most of them are sparingly soluble in water.

FLUENT, in *fluxions*; the flowing quantity, or that which is continually increasing or decreasing, whether line, surface, solid, &c.

FLUID; an appellation given to all bodies which yield, without separation, to the slightest pressure, easily move among themselves, and accommodate themselves to all changes of position, so as always to preserve a level surface. All fluids, except those in the form of air or gas, are incompressible in any considerable degree. All fluids gravitate or weigh in proportion to their quantity of matter, not only in the open air, or *in vacuo*, but in their own elements. Although this law seems so consonant to reason, it was supposed by ancient naturalists, who were ignorant of the equal and general pressure of all fluids, that the component parts, or the particles of the same element, did not gravitate or rest on each other; so that the weight of a vessel of water, balanced in air, would be entirely lost when the fluid was weighed in its own element.

The following experiment seems to leave this question perfectly decided: take a common bottle, corked close, with some shot in the inside to make it sink, and fasten it to the end of a scale beam; then immerse the bottle in water, and balance the weight in the opposite scale; afterwards open the neck of the bottle, and let it fill with water, which will cause it to sink; then weigh the bottle again. Now it will be found that the weight of the water which is contained in the bottle is equal to the difference of the weights in the scale, when it is balanced in air; which sufficiently shows that the weight of the water is the same in both situations. As the particles of fluids possess weight as a common property of bodies, it seems reasonable that they should possess the consequent power of gravitation which belongs to bodies in general. Therefore, supposing the particles which compose fluids to be equal, their gravitation must likewise be equal; so that in the descent of fluids, when the particles are stopped and supported, the gravitation being equal, one particle will not have more propensity than another to change its situation; and, after the impelling force has subsided, the particles will remain at absolute rest.

From the gravity of fluids arises their pressure, which is always proportioned to the gravity. For if the particles of fluids have equal magnitude and weight, the gravity or pressure must be proportional to the depth, and equal in every horizontal line of fluid; consequently, the pressure on the bottom of vessels is equal in every part. The pressure of fluids upwards is equal to the pressure downwards, at any given depth. For, suppose a column of water to consist of any given number of particles, acting upon each other in a perpendicular direction, the first particle acts upon the second with its own weight only; and, as the second is stationary, or fixed by the surrounding particles, according to the third law of motion, that action and reaction are equal, it is evident that the action or gravity, in the first, is repelled in an equal degree by the reaction of the second; and, in like manner, the second acts on the third, with its own gravity added to that of the first; but still the reaction increases in an equivalent degree, and so on throughout the whole depth of the fluid.

The particles of a fluid, at the same depth, press each other equally in all directions. This appears to rise out of the very nature of fluids; for, as the particles give way to every impressive force, if the pressure amongst themselves should be unequal, the fluid could never be at rest, which is contrary to experience; therefore we conclude that the particles press each other equally, which keeps them in their own places. This principle applies to the whole of a fluid as well as a part. This disposition on the part of all fluids to preserve a state of equilibrium between themselves may be illustrated by a very simple experiment.

If we take a deep glass vesssel, and having filled it with water, immerse in it another tube, closed at top, the tendency to a state of equilibrium will be apparent by the compression of the air in the tube; but if we withdraw the cork, the water will ascend, the upper pressure of the fluid being as great as that which tends to keep the water in the vessel.

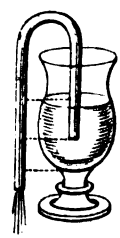
If four or five glass tubes, of different forms, be immersed in water, when the corks in the ends are taken out, the water will flow through the various windings of the different tubes, and rise in all of them to the same height as it stands in the straight tube; therefore the drops of fluids must be equally pressed, in all directions, during their ascent through the various angles of the tube; otherwise the fluid could not rise to the same height in them all. From the mutual pressure and equal action of the particles of fluids, the surface will be perfectly smooth, and parallel to the horizon. If, from any exterior cause, the surface of water has some parts higher than the rest, these will sink down by the natural force of their own gravitation, and diffuse themselves into an even surface. (See HYDROSTATICS.)

FLUIDITY; the state of bodies when their parts are very readily movable in all directions with respect to each other. Many useful and curious properties arise out of this modification of matter, which form the basis of the mechanical science called *hydrostatics*, and are of considerable importance in chemistry. But the attention of the chemist is chiefly directed to the state of fluidity as it may affect the component parts of bodies. A solid body may be converted into a fluid by heat. The less the temperature at which this is effected, the more fusible the body is said to be.

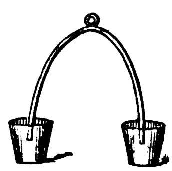
All fluids, not excepting the fixed metals, appear, from various facts, to be disposed to assume the elastic form, and this the more readily the higher the temperature. When a fluid is heated to such a degree that its elasticity is equal to the pressure of the air, its interior parts rise up with ebullition. The capacity of a dense fluid for caloric is greater than that of the same body when solid, but less than when in the elastic state. If this were not the case, the assumption of the fluid and elastic state would be scarcely at all progressive, but effected, in most cases, instantly as to sense. (See CALORIC.) The state of dense fluidity appears to be more favourable to chemical combination than either the solid or elastic state. In the solid state, the cohesive attraction prevents the parts from obeying their chemical tendencies; and, in the elastic state, the repulsion be-

tween the parts has, in a great measure, the same effects.

FLUIDS, MOTION OF. This subject will be fully discussed under HYDRAULICS and PIPES; we here notice only a few general principles. The motion of fluids, viz., their descent below or rise above the common surface or level of the source or fountain, is caused either, 1. by the natural gravity or pressure of the fluid contained in the reservoir or fountain; or, 2. by the pressure or weight of the air on the surface of the fluid in the reservoir, when it is, at the same time, either taken off or diminished, on some part, in aqueducts or pipes of conduit; 3. by the spring or elastic power of compressed or condensed air, as in the common water engine; 4. by the force of pistons, as in all kinds of forcing-pumps, &c.; 5. by the power of attraction, as in the case of tides. There is one apparent exception to the laws of fluids which must be noticed here. In a syphon fluids ascend as well as descend, and actually rise to a point higher than their natural level.



We have in this case a cup partly filled with water, and a bent tube is seen drawing off its fluid contents. To cause the water to flow over the top of the tube, the lips must be applied at the lower extremity, and having exhausted it of the air, the pressure of that without drives up the water, and the flow will continue as long as any remains in the vessel. Now the real cause of the ascent of the fluid in the first limb may be traced to the fact of the second tube being longer, and, as such, its fluid contents heavier. It descends by the ordinary laws of gravitation, and a new portion is continually forced up to supply its place.



A very beautiful application of this instrument to domestic purposes is shown in the diagram. Two little cups which may be firmly attached to the lower limbs of the syphon, at all times fit it for use by retaining the fluid in the tube. It is also of great importance for decanting acrid fluids, as acids, which might burn the lips of the operator.

FLUOR-SPAR. See MINERALOGY.

FLUORIC ACID is prepared by mixing pure fluor-spar, in coarse powder, with twice its weight of sulphuric acid, in a leaden or silver retort, and applying heat. The acid distils over in vapour, and must be collected in a receiver of the same metal surrounded by ice. At the temperature of 32° Fahrenheit, fluoric acid is a colourless fluid, and remains in that state at 59°, if preserved in well stopped bottles; but when exposed to the air, it flies off in dense white fumes, which consist of the acid in combination with the moisture of the atmosphere. Its specific gravity is 1.0609; but its density may be increased, by gradual additions of water, to 1.25. Its affinity for water is far greater than that of the strongest sulphuric acid. When a drop of it falls into water, a hissing noise is heard, similar to what is occasioned by plunging a red-hot iron into that liquid. Its odour is extremely penetrating, and its vapour dangerous to inspire. When applied to the skin, it instantly disorganizes it, and produces the most painful wounds. It acts energetically on glass; the transparency of the glass is instantly destroyed, caloric is evolved, and the acid boils, and, in a short time, disappears entirely, a colourless gas being the sole product.

This gas has received the name of *fluo-silicic acid*, because it is regarded as a compound of fluoric acid and silica. Another mode of procuring it in a visible state is to mix fluor-spar with pounded glass, and, introducing the mixture into a glass retort, to add sulphuric acid, and apply heat: the gas will make its appearance in abundance, and may be received in glass jars over the mercurial bath. It is about 48 times denser than hydrogen. When brought into contact with water, it is instantly absorbed, depositing its silica in a white, gelatinous mass, which is a hydrate of silica. It produces white fumes when suffered to pass into the atmosphere. From the strong affinity of fluoric acid for silica, it cannot be preserved in glass bottles; and is therefore kept in vessels of lead or silver. For the same reason, fluoric acid is employed for etching on glass—its only important application. The glass is covered with a thin coat of wax, or is brushed over with a solution of isinglass in water; and, when this is dried, lines are easily traced by a graver. It is then exposed to the action of the acid in the state of gas; the parts of the glass thus exposed are soon corroded, the impression being more or less deep, according to the time during which it is exposed. Such a method, were it possible to obviate completely the defect from the brittleness of glass, has, from the hardness of that substance, the important advantage over copper, that the impressions do not become less delicate from the fineness of the lines being diminished by the pressure in throwing them off. Different methods have been proposed to render the method practicable; and engravings, though not of much delicacy, have even been taken.

As all other acids are compound, Gay-Lussac and Thénard conceived the fluoric acid as such also, and adopted the opinion that it is composed of a certain combustible body and oxygen gas. They accordingly attempted to decompose it by means of some substance which has a strong affinity for oxygen, and employed potassium for that purpose. When that metal is brought into contact with fluoric acid, a violent action ensues, accompanied with an explosion, unless the experiment is cautiously conducted. Hydrogen gas is disengaged, and a white solid is produced, which has all the properties of fluate of potash; the explanation of which, given upon this view, was, that the hydrogen arises from the decomposition of water, that the oxygen of that fluid combines with the potassium, and that the potash so formed unites with the fluoric acid. They infer, therefore, from their experiments, that the strongest fluoric acid hitherto prepared contains water.

On the other hand, Sir H. Davy contended that fluoric acid, in its strongest form, is anhydrous; for, on combining it with ammoniacal gas, a dry fluate of ammonia is formed, from which no water can be expelled by heat. He maintained, also, that fluoric acid is composed, not of an inflammable base and oxygen, but of hydrogen united with a negative electric body, analogous to chlorine, to which he has given the name of *fluorine*. According to this view, when the metal potassium is brought into contact with fluoric acid, the hydrogen is not derived from water, but from the acid, and the supposed fluate of potash is a compound of fluorine and potassium.

The phenomena are explained with the same ease by either theory, although the arguments upon which they depend are thought, by the majority of chemists, to preponderate in favour of the view proposed by Sir Humphry Davy. Fluoric acid forms salts by uniting with several bases. Five fluates have hitherto been found native; viz., the fluate of lime, or fluor-spar, the fluo-silicate of alumine, or topaz, the fluate of cerium, the double fluate of cerium and yttria, and the double fluate of soda and alumine, or cryolite. The four latter are very rare minerals, but the first is abundant. Potash unites with fluoric acid in two proportions, forming a fluate and a bifluate, the former of which consists of one atom, and the latter of two atoms of acid united with one atom of the alkali.

A neutral fluate of soda may be obtained directly from fluoric acid and carbonate of soda. It melts with more difficulty than glass; 100 parts of water, at 212° Fahrenheit, dissolve only 4.3 of it. Neutral fluate of ammonia is more volatile than sal-ammoniac. It is easily obtained by heating one part of dry sal-ammoniac, with a little more than two parts of fluate of soda, in a crucible of platinum, with its lid turned upwards. The earthy fluates are best formed by digesting their recently precipitated moist carbonates in an excess of fluoric acid. That of barytes is slightly soluble in water, and readily in muriatic acid.

The neutral fluates of fixed bases are fusible at a high temperature, and are not decomposed by heat and combustible matter; nor does any acid, excepting the boracic, effect their decomposition, provided they are free from moisture. When digested, on the contrary, in concentrated sulphuric, phosphoric, or arsenic acids, the fluoric acid is disengaged, and may be recognised by its property of corroding glass. If, instead of glass, the fluor-spar be mixed with dry vitreous boracic acid, and distilled in a glass vessel with sulphuric acid. the proportions being 1 part boracic acid, 2 fluor-spar and 12 sulphuric acid, the gaseous substance formed is of a different kind, and is called *fluo-boric acid*. Its density to that of air is as 2.371 to 1.000. It is colourless. Its smell is pungent. It cannot be breathed without suffocation. It extinguishes combustion, and reddens vegetable blues. It has no action on glass, but a very powerful one on vegetable and animal matter, converting them into a carbonaceous substance. It has a singularly great affinity for water. When it is mixed with air, or any gas which contains watery vapour, a dense white cloud appears, which is a combination of water and fluo-boric acid gas. From this circumstance, it forms an exceedingly delicate test of the presence of moisture in gases. Fluo-boric acid gas is rapidly absorbed by water.

When potassium is headed in fluo-boric acid gas, it inflames, and a chocolate-coloured solid, wholly devoid of metallic lustre, is the sole product. On putting this substance into water, a part of it dissolves, and a solution of fluate of potash is obtained, the insoluble matter being boron. Accordingly, fluoboric acid gas is inferred to be a compound of fluoric and boracic acids. It unites with ammoniacal gas in three proportions, forming salts, one of which is solid, and the two others liquid. Other compounds of this acid, with salifiable bases, are scarcely known.

Flute; a portable instrument, blown with the breath, and consisting of a tube of box or ivory, furnished with holes at the side for the purpose of varying its sounds. Its name is derived from the word *fluta*, the Latin name of the lamprey, or small eel taken in the Sicilian seas, because, like that fish, it is long and perforated at the side. The flute was in great esteem with the ancient Greeks and Romans. (See Tibiæ.)

The *German flute* is, as its name implies, a wind instrument of German invention, consisting of a tube formed of several joints or pieces screwed into each other, with holes disposed along the side, like those of the common flute. It is stopped at the upper end, and furnished with movable brass or silver keys, which, by opening and closing certain holes, serve to temper the tones to the various flats and sharps. In playing this instrument, the performer applies his under lip to a hole about two inches and a half from the upper extremity, while the fingers, by their action on the holes and keys, accommodate the tones to the notes of the composition.

Flutes, in *architecture;* channels or furrows cut perpendicularly in the shafts of columns. Fluting the shafts of columns is a practice never omitted in any great and finished Grecian work. It therefore seems probable that it had some relation to the original type: perhaps the furrowed trunk might have suggested the idea. It is, however, a beautiful ornament, which is applied with equal happiness to break the otherwise heavy mass of a Doric shaft or to obviate an inconsistent plainness in the other orders.

Flux; a general term made use of to denote any substance or mixture added to assist the fusion of minerals. In the large way, limestone and fluor-spar are used as fluxes. The fluxes made use of in assays, or philosophical experiments, consist usually of alkalies, which render the earthy mixtures fusible by converting them into glass.

Alkaline fluxes are either the crude flux, the white flux, or the black flux. Crude flux is a mixture of nitre and tartar, which is put into the crucible with the mineral intended to be fused. The detonation of the nitre with the inflammable matter of the tartar is of service in some operations, though generally it is attended with inconvenience on account of the swelling of the materials, which may throw them out of the vessel. White flux is formed by introducing equal parts of a mixture of nitre and tartar, by moderate portions at a time, into an ignited crucible. In the detonation which ensues, the nitric acid is decomposed, and flies off with the tartaric acid; and the remainder consists of the potash, in a state of considerable purity. This has been called *fixed nitre*. Black flux differs from the preceding in the proportion of its ingredients. In this the weight of the tartar is double that of the nitre, on which account the combustion is incomplete, and a considerable portion of the tartaric acid is decomposed by the mere heat, and leaves a quantity of coal behind, on which the black colour depends. It is used where metallic ores are intended to be reduced, and effects the purpose by combining with the oxygen of the oxide.

Fluxion, in the *Newtonian Analysis*, denotes the velocity with which a flowing quantity increases by its generative motion, by which it stands contradistinguished from a fluent or flowing quantity, which is constantly and indefinitely increasing, after the manner that a surface is described by the motion of a line, or a solid by the motion of a surface.

Or, a fluxion may be otherwise defined as the

magnitude by which any flowing quantity would be uniformly increased in a given portion of time, with the generating celerity, at any proposed position or instant, supposing it thence to continue invariable.

Fluxional Analysis, or analysis of fluxions and flowing quantities, is distinguishable from the differential calculus by its notation.

The invention of the fluxional analysis does more honour to the powers of the human mind than perhaps any discovery of this or any preceding age; it opens to us a new world, and extends our knowledge, as it were, to infinity; it carries us beyond those bounds which seem prescribed to our mental powers, and leads to investigations and results which must otherwise have ever remained in impenetrable obscurity.

Within the narrow compass to which this article must necessarily be confined, the reader will not expect a minute detail of the principles of fluxions. It will be sufficient to observe that all finite magnitudes are here conceived to be resolved into infinitely small ones, supposed to be generated by motion, as a line by the motion of a point, a superficies by a line, and a solid by a superficies,—of which they are the elements, moments, or differences.

The art of finding these infinitely small quantities, or the velocities by which they are generated, and of working on them, and discovering other infinite quantities by their means, makes what is called the *direct method of fluxions*. And the method of finding the fluents or flowing quantities, these fluxions being given, is what constitutes the *inverse method*.

What renders the knowledge of infinitely small quantities of such great use and extent is that they have relations to each other, which the finite magnitudes whereof they are the infinitesimals have not.

Thus, for example, in a curve of any kind whatever, the infinitely small difference of the ordinate and absciss have the ratio to each other, not of the ordinate and absciss, but of the ordinate and subtangent; and, of consequence, the absciss and ordinate being known, will give the subtangent; or, which amounts to the same, the tangent itself.

The method of notation in fluxions, introduced by the inventor, Sir Isaac Newton, is as follows:—

The variable or flowing quantity, to be uniformly augmented, as suppose the absciss of a curve, he denotes by the final letters v, x, y, z; and their fluxions by the same letters with dots placed over them, thus, $\dot{v}, \dot{x}, \dot{y}, \dot{z}$. And the initial letters a, b, c, d, &c., are used to express invariable quantities.

Again, if the fluxions themselves are also variable quantities, and are continually increasing or decreasing, he considers the velocities with which they increase or decrease, as the fluxions of the former fluxions, or second fluxions, which are denoted by two dots over them, thus, $\ddot{y}\ \ddot{x}\ \ddot{z}$.

After the same manner one may consider the increase and diminution of these as their fluxions also, and thus proceed to the third, fourth, &c., fluxions, which will be denoted thus, $\dddot{y}\ \dddot{x}\ \dddot{z}$, $\ddddot{y}\ \ddddot{x}\ \ddddot{z}$, &c.

Lastly, if the flowing quantity be a surd, as $\sqrt{x-y}$, he denotes its fluxion by $(\sqrt{x-y})^{\cdot}$; if a fraction $\frac{xx}{d-y}$, it is denoted by $\left(\frac{xx}{d-y}\right)$.

Sometimes, however, the fluxions of compound quantities are expressed by placing the letter F, or f, before them; thus, instead of $(\sqrt{(x-y)}^{\cdot})$, is written F. $\sqrt{(x-y)}$, or $f.\ \sqrt{(x-y.)}$ At other times the fluxion is denoted by F, and the fluent by f; so that

$$\left.\begin{array}{ll} \text{F.} & \sqrt{(x-y)} \\ \text{F.} & \dfrac{x+ax^2}{b+x} \end{array}\right\} \text{denote the fluxions of} \left\{\begin{array}{l} \sqrt{(x-y)} \\ \dfrac{x+ax^2}{b+x} \end{array}\right.$$

$$\left.\begin{array}{ll} f. & \dot{x}\sqrt{(x+ax^2)} \\ f. & \dfrac{\dot{x}b}{x+ax^2} \end{array}\right\} \text{denote the fluents of} \left\{\begin{array}{l} \dot{x}\sqrt{(x+ax^2)} \\ \dfrac{b\dot{x}}{x+ax^2} \end{array}\right.$$

(See SURDS.)

FLY is a name given to a certain appendage to many machines, either as a regulator of their motions or as a collector of power. When used as a regulator, the fly is commonly a heavy disk or hoop, balanced on its axis of motion, and at right angles to it; though sometimes a regulating fly consists of vanes or wings, which, as they are whirled round, meet with considerable resistance from the air, and thus soon prevent any acceleration in the motion; but this kind of regulator should rarely, if ever, be introduced in a working machine, as it wastes much of the moving force. When the fly is used as a collector of power, it is frequently seen in the form of heavy knobs at the opposite ends of the straight bar, as in the coining press.

FOCILE MAJUS, in *anatomy;* the greater bone of the arm, called *ulna;* or greater bone of the leg, called *tibia*. The lesser bone of the arm or leg is called *focile minus*.

FOCUS, in *optics*, is a point wherein several rays concur or are collected, after having undergone either refraction, or reflection. This point is thus denominated, because, the rays being here brought together and united, their joint effect is sufficient to burn bodies exposed to their action; and hence this point is called the *focus*, or burning point. It must be observed, however, that the focus is not, strictly speaking, a point; for the rays are not accurately collected into one and the same place or point, owing to the different nature and refrangibility of the rays of light, to the imperfections in the figure of the lens, and other similar impediments. The focus, therefore, is a small circle, which Huygens has demonstrated to be one eight the thickness of the lens, when it is convex on both sides; that is, it cannot be less than this, but, in imperfect glasses, it exceeds the above measure sometimes considerably.

FŒTUS, in *anatomy;* a term applied to the offspring of the human subject, or of animals, during its residence in the womb,

FOG. There is a constant ascent of watery particles from the surface of the earth, occasioned by the evaportation from masses of water and moist bodies. Part of the water which rises in vapour is intimately united with the atmospheric air, which holds it in solution. This portion of aqueous matter is invisible, and exists in the greatest quantity in very warm and serene weather. Thus, in the hot days of summer, any cold body (as a vessel filled with iced water) is immediately covered with little globules of water, which are the vapour of the atmosphere precipitated. But when the air is saturated, the watery particles which continue to rise are no longer dissolved, but remain suspended in vesicular vapours, which form clouds when they rise to a great height, and fogs when they hover near the surface of the earth.

Fogs are more frequent in those seasons of the year when there is a considerable difference of temperature in the different parts of the day; as, for instance, in autumn, when, in the warmest part of the day, the air is capable of holding a great quantity of aqueous matter in solution, which, on cooling towards evening, it is no longer capable of dissolving. In hot weather, the air is not so easily saturated, and in cold weather, the process of evaporation is very slow, so that, in these cases, fogs are less common. In low, moist places, and in confined places, as valleys, forests, bays or lakes, surrounded by high lands, they are much more prevalent than in open countries, or elevated spots, where they are quickly dispersed by the winds. Fogs are very frequent in the arctic regions, where the sudden depression of temperature is enormously below the mean temperature. Fogs will be most frequent over shallow water, which sooner partakes of the temperature of the bottom than the deep water. The end of the deep water is known near the banks of Newfoundland, by the sudden commencement of the fogs. The thick fogs which appeared during Captain Franklin's expedition, prove that the sea is very shallow, and the mean temperature not very low, upon that part of the arctic coast.

There is another atmospherical phenomenon, which has been called *dry fogs*. In 1783, all Europe was enveloped with a dry fog, at the moment of a simultaneous volcanic action in Iceland and Calabria. In 1755, before the earthquake which destroyed Lisbon, a similar fog overspread the Tyrol and Switzerland. It appeared to be composed of earthy particles reduced to an extreme degree of fineness. A *fog-bank* is an appearance in hazy weather, which frequently resembles land at a distance, but which vanishes as you approach it.

Foil; a thin leaf of metal, placed under transparent substances, such as precious stones, for the sake of improving their colour, and heightening their lustre, the light, which passes through the transparent body, being reflected by the metal. Figuratively, any thing that serves to set off another object, by improving its external appearence.

Foil is also used to signify the sheet of amalgam laid on the back side of a mirror, which enables it to reflect a complete image.

Foil, in *fencing;* a blunt sword, or one tipped with a button or cork, covered with leather.

Foliage, in *architecture;* a kind of ornament in cornices, friezes, &c., representing the leaves of plants.

Fomahant, in *astronomy;* a fixed star, of the first magnitude, in the constellation Aquarius.

Fomentation, in *medicine*, is the external application of a fluid, as warm as the patient can bear it. Two flannel cloths are dipped in that liquor, one of which is wrung as dry as possible, and immediately applied to the part affected. This cloth lies on till the heat has evaporated, and the other is then applied. By this alternate application, the part affected is constantly supplied with warmth, for 15 minutes, or half an hour, as occasion may require.

Food, *comparative nutritive properties of*. An interesting report on this subject was presented to the French minister of the interior, by Messrs. Percy and Vauquelin, members of the Institute. In bread, every 100lbs. is found to contain 80lbs. of nutritious matter; butcher meat, averaging the different sorts, contains only 35lbs. in 100; French beans (in the grain), 92lbs. in 100; broad beans 89lbs.; peas, 93 lbs.; lentils (a species of half pea, little known in this country), 94lbs. in 100; greens and turnips, which are the most aqueous of all vegetables used in culinary purposes, furnish only 8 lbs. of solid nutritious substance in 100; carrots (from whence an inferior kind of sugar is produced), 14lbs.; and what is remarkable, as being opposed to the old theory, 100lbs. of potatoes yield only 25 lbs. of nutriment; 1 lb. of good bread is equal to 2½lbs. of potatoes; and 75lbs. of bread and 30lbs. of meat are equal to 300lbs. of potatoes; ½lb. of bread and 5oz. of meat are equal to 3lbs. of potatoes; 1 lb. of potatoes is equal to 4 lbs. of cabbage and 3lbs. of turnips; and 1lb. of rice bread or French beans is equal to 3 lbs. of potatoes.

Food, *abstinence from*. The more that animals enjoy the qualities of youth, strength, and activity, the greater is the increase and developement of their parts, and the greater the necessity for an abundant supply of food. Of many individuals exposed to an absolute abstinence of many days, the young are always the first to perish. Of this the history of war and shipwreck offers in all ages too many frightful examples. There are several instances on record, of entire abstinence from food for an extraordinary length of time. Captain Bligh, of the Bounty, sailed almost 4,000 miles in an open boat, with occasionally a single small bird not many ounces in weight, for the daily sustenance of seventeen people. In the opinion of Rhedit, animals support want much longer than is generally believed. A civet cat lived ten days without food, an antelope twenty, and a very large wild cat also twenty; an eagle survived twenty-three day, a badger one month, and several dogs thirty-six days. In the *Memoirs of the Academy of Sciences*, there is an account of a bitch, which having been accidently shut up alone in a country house, existed for forty days without any other nourishment than the stuff on the wool of a mattress, which she had torn to pieces. A crocodile will live two months without food, a scorpion three, a bear six, a chameleon eight, and a viper ten. Valliant had a spider that lived nearly a year without food, and was so far from being weakened by abstinence, that it immediately killed another large spider, equally vigorous but not so hungry, which was put in along with it. John Hunter inclosed a toad between two stone flower-pots and found it as lively as ever after fourteen months. Land-tortoises have lived without food for eighteen months; and Baker is known to have kept a beetle in a state of abstinence for three years. It afterwards made its escape. Dr. Shaw gives an account of two serpents which lived in a bottle without any food for five years.

Foot; a measure of length, derived from the length of the human foot, containing 12 linear inches.

Square foot, is a square whose side is one foot, and is therefore equal to 144 square inches.

Cubic foot, is a cube whose side is one foot, and the cube contains 1728 cubic inches.

Forage, in *military* affairs, denotes the provisions brought into the camp by the troops for the sustenance of the horses.

Foramen, in *anatomy;* a perforation or opening, as—*Foramen cæcum*, an opening at the basis of the cranium; and also in the middle of the tongue. *Foramen opticum*, the hole transmitting the optic nerve, &c.

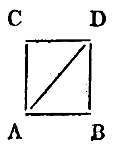
Force, in *mechanics*, denotes that unknown cause

which produces a change in the state of a body, as to motion, rest, pressure, &c.; that is, whatever produces or tends to produce motion, or a change of motion in any body, is called *force*. According to this definition, the muscular power of animals, as likewise pressure, impact, gravity, &c., are considered as forces, or sources of motion, it being evident, from daily experience, that bodies exposed to the free action of any of these are either put into motion, or have their state of motion changed. All forces, however various, are measured by the effects which they produce in like circumstances, whether the effect be creating, accelerating, retarding, or deflecting motions; the result of some general and commonly observed force is taken for unity, and with this any others may be compared, and their proportions represented by numbers or lines. Under this point of view they are considered by the mathematician; all else falls within the province of the universal philosopher, or the metaphysician.

When we say that a force is represented by a right line, A B, it is to be understood that it would cause a material point, situated at rest in A, to run over the line A B, which is called the direction of the force, so as to arrive at B at the end of a given time, while another force would cause the same point to have moved a greater or less distance from A in the same time. (*See the figure below.*) Mechanical forces may be reduced to two sorts; one of a body at rest, the other of a body in motion. The former is that which we conceive as residing in a body when it is supported by a plane, suspended by a rope, or balanced by the action of a spring, &c., being denominated *pressure, tension, force*, or *vis mortua, solicitatio, conatus movendi*, and which may always be estimated or measured by a weight, viz., the weight that sustains it. To this class of forces may also be referred centripetal and centrifugal forces, though they reside in a body in motion, because these forces are homogeneous to weights, pressures, or tensions of any kind.

The force of a body in motion is a power residing in that body so long as it continues its motion; by means of which it is able to remove obstacles lying in its way, to lessen, destroy, or overcome the force of any other moving body, which meets it in an opposite direction; or to surmount the largest dead pressure or resistence, as tension, gravity, friction, &c., for some time, but which will be lessened or destroyed by such resistance as lessens or destroys the motion of the body. This is called *vis motrix*, moving force, or motive force, and, by some late writers, *vis viva*, to distinguish it from the *vis mortua*, spoken of before.

Composition of Forces may be thus defined: If two or more forces, differently directed, act upon the same body, at the same time, as the body in question cannot obey them all, it will move in a direction somewhere between them. This is called the *composition* and *resolution* of forces or of motion, and may be illustrated in the following manner: Suppose a body, A, to be acted upon by a force in the direction A B, while, at the same time, it is impelled by another force in the direction A C, it will then move in the direction A D; and if the lines A B, A C, be made of lengths proportionate to the forces, and the lines C D,



D B, be drawn parallel to them, so as to complete the parallelogram A B D C, then the line which the body A will describe, will be the diagonal A D; and the length of this line will represent the force with which the body will move. But if the body be impelled by equal forces, acting at right angles to each other, it will move in the diagonal of a square. Instances in nature, of motion produced by several powers acting at the same time, are innumerable. A ship impelled by the wind and tide is one well known; a paper kite acted upon in one direction by the wind, and in another by the string, is another instance.

Animal Force, as applied to Machinery. All machines are impelled either by the exertion of animal force or by the application of the powers of nature. The latter comprise the potent elements of water, air, and fire. The former is more common, yet so variable as hardly to admit of calculation. It depends not only on the vigour of the individual, but on the different strength of the particular muscles employed. Every animal exertion is attended by fatigue; it soon relaxes, and would speedily produce exhaustion. The most profitable mode of applying the labour of animals, is to vary their muscular action, and revive its tone by short and frequent intervals of repose.

The ordinary method of computing the effects of human labour is, from the weight which it is capable of elevating to a certain height in a given time, the product of these three numbers expressing the absolute quantity of performance. This was reckoned by Daniel Bernoulli and Desagulier at 2,000,000 lbs. avoirdupois, which a man could raise one foot in a day. But our civil engineers have gone much farther, and are accustomed, in their calculations, to assume, that a labourer will lift 10 lbs. to the height of ten feet every second, and is able to continue such exertion for ten hours each day, thus accumulating the performance of 3,600,000. But this estimate seems to be drawn from the produce of momentary exertions, under the most favourable circumstances; and it therefore greatly exceeds the actual results, as commonly depressed by fatigue, and curtailed by the unavoidable waste of force.

Coulomb has furnished the most accurate and varied observations on the measure of human labour. A man will climb a stair, from 70 to 100 feet high, at the rate of 45 feet in a minute. Reckoning his weight at 155 lbs., the animal exertion for one minute is 6975, and would amount to 4,185,000 if continued for ten hours. But such exercise is too violent to be often repeated in the course of a day. A person may clamber up a rock 500 feet high, by a ladder-stair, in 20 minutes, and, consequently, at the rate of 25 feet each minute; his efforts are thus already impaired, and the performance reaches only 3875 in a minute. But, under the incumbrance of a load, the quantity of action is still more remarkably diminished. A porter, weighing 140 lbs., was found willing to climb a stair 40 feet high 266 times in a day; but he could carry up only 66 loads of firewood, each of them 163 lbs. weight. In the former case, his daily performance was very nearly 1,500,000; while, in the latter, it amounted only to 808,000. The quantity of permanent effect was hence only about 700,000, or scarcely half the labour exerted in mere climbing.

In the driving of piles, a load of 42 lbs., called the *ram*, is drawn up $3\frac{1}{2}$ feet high 20 times in a m

nute; but the work has been considered so fatiguing as to endure only three hours a day. This gives about 530,000 for the daily performance. Nearly the same result is obtained, by computing the quantity of water which, by means of a double bucket, a man drew up from a well. He lifted 36 lbs. 120 times in a day, from a depth of 120 feet, the total effect being 518,400. A skilful labourer working in a field with a large hoe, creates an effect equal to 728,000. When the agency of a winch is employed in turning a machine, the performance is still greater, amounting to 845,000. In all these instances, a certain weight is heaved up, but a much smaller effort is sufficient to transport a load horizontally.

A man could, in the space of a day, scarcely reach an altitude of two miles by climbing a stair; though he will easily walk over 30 miles on a smooth and level road. But he would, in the same time, carry 130 lbs. only to the fourth part of that distance, or 7½ miles. Assuming his own weight to be 140 lbs., the quantity of horizontal action would amount to 42,768,000, or 28 times the vertical performance; but the share of it in conveying the load is 20,961,780, or about 30 times what was spent in its elevation. The greatest advantage is obtained by reducing the burden to 102 lbs., the length of journey being augmented in a higher ratio. These results are apparently below the average of English labour, which is not only more vigorous, but in many cases quite overstrained. Moderate exertion of strength, joined to regularity and perseverance, would be more conducive to robust health and the comfortable duration of human life.

A porter in London is accustomed to carry a burden of 200 lbs. at the rate of three miles an hour. In the same metropolis, a couple of Irish chairmen continue, at the pace of four miles an hour, under a load of 300 lbs. These exertions are greatly inferior, however, to the labour performed by porters in Turkey, the Levant, and generally on the shores of the Mediterranean.

At Constantinople, an Albanian porter will carry 800 or 900 lbs. on his back, stooping forward, and assisting his steps by a sort of staff. At Marseilles, four porters commonly carry the immense load of nearly two tons, by means of soft hods passing over their heads, and resting on their shoulders, with the ends of poles, from which the goods are suspended. According to some experiments of the late Mr. Buchanan, the exertions of a man in working a pump, in turning a winch, in ringing a bell, and in rowing a boat, are as the numbers 100, 167, 227, and 248. But those efforts appear to have been continued for no great length of time.

The Greek seamen, in the Dardanelles, are esteemed more skilful and vigorous in the act of rowing, than those of any other nation. The Chinese, applying both their hands and their feet, are said to surpass all people in giving impulsion to boats by sculling. The several races of men differ materially in strength, but still greater diversity results from the constitution and habits of the individual. The European and his American descendants are, on the whole, more powerful than the other inhabitants of the globe; and man, reared in civilized society, is a more robust and vigorous animal than the savage. In the temperate climates, likewise, men are capable of much harder labour than under the influence of a burning sun. Coulomb remarks, that the French soldiers, employed on the fortifications of the Isle of Martinique, became soon exhausted, and were unable to perform half the work executed by them at home. The most violent and toilsome exertion of human labour is performed in Peru, by the carriers, or *cargueros,* who traverse the loftiest mountains, and clamber along the sides of the most tremendous precipices, with travellers seated on chairs strapped to their backs. In this manner, they convey loads of 12, 14, or even 18 stone; and possess such strength and action, as to be able to pursue their painful task eight or nine hours, for several successive days. These men are a vagabond race, consisting mostly of mulattoes, with a mixture of whites, who prefer a life of hardship and vicissitude to that of constant though moderate labour. When a man stands, he pulls with the greatest effect; but his power of traction is much enfeebled by the labour of travelling.

If v denote the number of miles which a person walks in an hour, the force which he exerts in dragging forward a load will be expressed nearly by $\frac{1}{5}(12-2v)^2$. Thus, when at rest, he pulls with a force of about 29 lbs. avoirdupois; but if he walks at the rate of two miles an hour, his power of traction is reduced to 14 lbs.; and if he quickens his pace to four miles an hour, he can draw only 3 lbs. There is, consequently, a certain velocity which procures the greatest effect, or when the product of the traction by the velocity becomes a maximum. This takes place when he proceeds at the rate of two miles an hour. The utmost exertion which a man, walking, might continue to make, in drawing up a weight by means of a pulley, would amount, therefore, in a minute, only to 2430; but if he applied his entire strength, without moving from the spot, he could produce an effect of 3675.

The labour of a horse in a day is commonly reckoned equal to that of five men; but then he works only eight hours, while a man easily continues his exertions for ten hours. Horses, likewise, display much greater force in carrying than in pulling; and yet an active walker will beat them on a long journey. Their power of traction seldom exceeds 144 pounds, but they are capable of carrying more than six times as much weight. The pack-horses in the West Riding of Yorkshire were accustomed to transport loads of 420 lbs. over a hilly country. But, in many parts of England, the mill-horses will carry the enormous burden of 910 lbs. to a short distance. With regard, however, to the ordinary power of draught, the formula $(12-v)^2$, where v denotes the velocity in miles an hour, will, perhaps, be found sufficiently near the truth. Thus a horse, beginning his pull with the force of 144 lbs., would draw 100 lbs. at a walk of two miles an hour, but only 64 lbs. when advancing at double that rate, and not more than 36 lbs. if he quickened his pace to six miles an hour. His greatest performance would hence be made with the velocity of four miles an hour. The accumulated effort in a minute will then amount to 22,528. The measure generally adopted for computing the power of steam-engines is much higher, the labour of a horse being reckoned sufficient to raise, every minute, to the elevation of one foot, the weight of 32,000 lbs. But this estimate is not only greatly exaggerated, but should be viewed as merely an arbitrary and conventional standard.

Wheel carriages enable horses, on level roads, to draw, at an average, loads about 15 times greater

than the power exerted. The carriers between Glasgow and Edinburgh transport, in a single-horse cart, weighing about 7 cwt., a load of a ton, and travel at the rate of 22 miles a day. At Paris, one horse, in a small cart, conveys along the streets half a cord of wood, weighing two tons; but three horses, yoked in a line, are able to drag 105 cwt. 5¼ lbs., or that of a heavy cart loaded with building stones. The Normandy carriers travel from 14 to 22 miles a day, with two-wheeled carts, weighing each 11 cwt., and loaded with 79 cwt., or nearly 4 tons of goods, drawn by a team of four horses. The French draught horses, thus harnessed to light carriages, are more efficient, perhaps, than the finer breeds of this country. They perform very nearly as much work as those in the single-horse carts used at Glasgow, and far greater than those fine yet heavy animals which drag the towering waggons in this country. The London draught horses, in the mere act of ascending from the wharfs, display a powerful effort, but they afterwards make little exertion, their force being mostly expended in transporting their own ponderous mass along.

Oxen, on account of their steady pull, are in many countries preferred for draught. They were formerly employed universally in the various labours of husbandry. The tenderness of their hoofs, unless shod, however, makes them unfit for pulling on paved roads, and they can work only with advantage in soft grounds. But they want all the pliancy and animation which are the favourite qualities of the horse. The patient drudgery of the ass renders him a serviceable companion of the poor. Much inferior in strength to the horse, he is maintained at far less cost. In America, an ass will carry about two hundred weight of coals or limestone twenty miles a day. But, in the warmer climates, he becomes a larger and finer animal, and trots or ambles briskly under a load of 150 pounds. The mule is still more powerful and hardy, being fitted equally for burden and draught.

In the hotter parts of Asia and Africa, the ponderous strength of the elephant has been long turned to the purposes of war. He is reckoned more powerful than six horses, but his consumption of food is proportionally great. The elephant carries a load of three or four thousand pounds; his ordinary pace is equal to that of a slow trot; he travels easily over forty or fifty miles in a day, and has been known to perform in that time a journey of one hundred and ten miles. His sagacity directs him to apply his strength according to the exigency of the occasion.

The camel is a most useful beast of burden in the arid pains of Arabia. The stronger ones carry a load of ten or twelve hundred weight, and the weaker ones transport six or seven hundred; they walk at the rate of two miles and a half in an hour, and march about thirty miles every day. The camel travels often eight or nine days without any fresh supply of water. When a caravan encamps in the evening, he is perhaps turned loose, for the space of an hour, to browze on the coarsest herbage, which serves him to ruminate during the rest of the night. In this manner, without making any other halt, he will perform a dreary and monotonous journey of two thousand miles.

Within the arctic circle, the rein-deer is a domesticated animal, not less valuable. He not only feeds and clothes the poor Laplander, but transports his master, with great swiftness, in a covered sledge, over the snowy and frozen tracts. The rein-deer subsists on the scanty vegetation of moss or lichens, and is docile, but not powerful. Two of them are required to draw a light sledge: so harnessed, they will run fifty or sixty miles on a stretch, and sometimes perform a journey of a hundred and twelve miles in the course of a day. But such exertions soon wear them out. A sort of dwarf camel was the only animal of burden possessed by the ancient Peruvians.

The lama is, indeed, peculiarly fitted for the lofty regions of the Andes. The strongest of them carry only from 150 to 200 pounds, but perform about fifteen miles a day over the roughest mountains. They generally continue this labour during five days, and are then allowed to halt two or three days before they renew their task. The paco is a similar animal, employed likewise in transporting heavy goods in that singular country; it is very stubborn, however, and carries only from fifty to seventy pounds. Even the exertions of goats have, in some parts of Europe, been turned to useful labour. They are made to tread in a wheel which draws water, or raises ore from the mine. Though a very light animal, the goat exerts much force, as he climbs at a high angle. Supposing this soaring creature, though only the fourth part of the weight of a man, to march as fast along an ascent of 40°, as he does over one of 18°, the sine of the former being double that of the latter,—it must perform half as much work.

Forceps, in *surgery*, &c.; a pair of scissors for cutting off, or dividing, the fleshy, membranous parts of the body, as occasion requires.

Fore; the distinguishing character of all that part of a ship's frame and machinery which lies near the stem.

Forecastle; a short deck placed in the fore part of a ship, above the upper deck; it is usually terminated, both before and behind, in vessels of war, by a breast-work, the foremost part forming the top of the beak head, and the hind part reaching to the after-part of the fore chains. — *Forecastle Men;* sailors stationed on the forecastle, who are generally experienced seamen.

Foreshortening, in *drawing* and *painting;* the art of representing figures of all sorts as they appear to the eye, in oblique positions. This art, which, in many instances, is very difficult, was known to the Greeks; and Pliny speaks particularly as to its being sucessfully practised by Parrhasius and Pausias. Among the moderns, Correggio must be allowed the palm for excellence in foreshortening. In painting ceilings, it is particularly important. In a celebrated picture of the body of Christ lying horizontally, the figure is so much foreshortened that the toes appear almost to touch the chin.

Forge; a small furnace, as that used by smiths, &c., or simply, a pair of bellows, the muzzle of which is directed upon a smooth area, on which coals are placed. This term is also used when speaking of a large furnace, in which iron ore, taken out of the mine, is melted down; or it is more properly applied to another kind of furnace, wherein the iron ore, melted down, and separated in a former furnace, and then cast into sows and pigs, is heated and fused over again, and beaten afterwards with large hammers, and thus rendered more soft, pure, ductile, and fit for use. The forge furnace consists of a hearth,

upon which a fire may be made, and urged by the action of a large pair of double bellows, the nozzle of which is inserted through a wall or parapet constructed for that purpose. Black-lead pots, or small furnaces of every desired form, may be placed, as occasions require, upon the hearth; and, the tube of the bellows being inserted into a hole in the bottom of the furnace, it becomes easy to raise the heat to almost any degree required.

Forestalling is the buying or bargaining for any corn, cattle, or other merchandise, by the way, before it comes to any market or fair to be sold, or as it comes from beyond the seas, or otherwise, towards any port or creek, to sell the same again at a higher price. At the common law, all endeavours to enhance the price of merchandise, and all practices which have a tendency thereto, whether by spreading false rumours, or by purchasing things in a market before the accustomed hour, or by buying and selling again the same thing in the same market, or by such devices, are criminal, and punishable by fine and imprisonment.

Forlorn Hope, in the *military art*, signifies men detached from several regiments, or otherwise appointed, to make the first attack in the day of battle, or, at a siege, to storm the counterscrap, mount the breach, or the like. They are so called from the great danger they are unavoidably exposed to.

Form, Printer's; an assemblage of letters, words, and lines, disposed into pages by the compositor, and from which the printed sheets are taken.

Formic Acid; thus named from having been discovered first in the expressed liquor of ants; at present it is procured from the application of a gentle heat to a mixture of tartaric acid, water, and the protoxide of manganese. The tartaric acid is converted into water, carbonic acid, and formic acid. This acid has a very sour taste, and continues liquid at very low temperatures. Its specific gravity is 1.1068 at 68° Fahr. M. C. G. Gmelin has prepared formic acid from cane sugar, sugar of milk, starch, wood, the root of the *althæa*, mucic acid, &c., by distilling those bodies with dilute sulphuric acid and peroxide of manganese; but the formic acid thus obtained is always impure. He has, however, obtained it in a high state of purity, by distilling alcohol with sulphuric acid and oxide of manganese. But, to prevent the formation of ether, dilute alcohol must always be employed; common spirits of wine is the most convenient. Concentrated alcohol produces not only sulphuric ether, but also formic ether. The fibrin of the blood furnishes a very impure formic acid. According to Berzelius, the formiate of lead consists of 4.696 acid and 14 oxide of lead; and the ultimate constituents of the dry acid are hydrogen 2.84, carbon 32.40, oxygen 64.76.

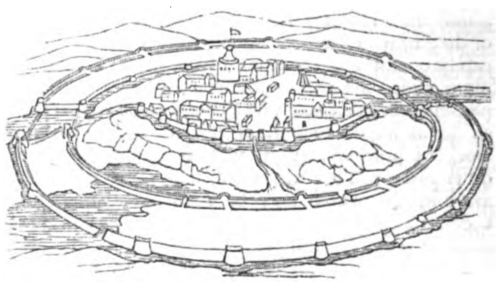
Fort; a small fortified place, surrounded with a ditch, rampart, and parapet, for the purpose of defending a pass, river, road, harbour, &c. Forts are made of different forms and extent, according to the exigencies of the case.

Forte. See Piano.

Fortification, as a science, had no place in the military history of ancient times. The details furnished in Scripture prove incontestibly, that even the circumvallations used by the Jewish people were inadequate to the purposes of security and duration. In fact, the events that shone conspicuous in those times were, with very few exceptions, pitched battles in the open plain, or ambuscades. Nor do we find in the more recent histories of Rome, of Greece, or of Asia, much to support the opinion of the ancients having a knowledge of fortification. The few places that made any resistance appear to have been principally maintained by the personal prowess of their defenders. Their walls were, indeed, sometimes of great extent, as we see in the instance of Troy; which, existing in eighteenth century, would probably capitulate at the first summons.

It was not to be expected, where the powers of demolition were insignificant, the means of resistance would be extended beyond the quantum absolutely necessary. The catapulta, the battering-ram, the tower, and such devices, were opposed by heavy masses of stone, or of other adequate materials, on which the besieged mounted to repel the assault. The various contrivances by which those machines received additional vigour, and the necessity that arose for opposing to their progress more resistance than could be accumulated immediately in their front (of the tower in particular), first give rise to the introduction of projections from the even line of the wall, whereby the besiegers could be annoyed laterally, as well as immediately front to front.

Still the engineer confined himself to small projections, generally semicircular, which, for the most part, appear to have been added to the old walls, impending like our modern balcony windows. In the sequel, these towers were built the same as the other parts of the circumvallation, and, like the modern bastion, rested on the firm ground. It however seems doubtful, whether the former mode was not the best, considering every circumstance attendant upon the ancient mode of assault, and the nature of their weapons.



The above view will serve to furnish the reader with some notion of the earliest state of methodical fortification. The great object seems to have been, by double and sometimes triple lines of walls to increase the means of resistance, by protracting the advance of the enemy.

The invention of gunpowder does not appear to have led to any important change for several years; nor indeed until heavy artillery formed a part of the assailants' means, as may be proved by an examination of the castles and towns still remaining. Such were the solidity and hardness of many ancient buildings, that the stone shots, originally used, produced a very slight effect; nor was it until iron balls were brought into use, that the powers of cannon were in any measure ascertained.

That point being gained, the whole system of defence was necessarily made to conform to the destructive engines which were now added to the common

practice of assault. The sword, buckler, lance, dart, javelin, sling, bow and arrow, lost their wonted estimation, and, dwindling into insignificance on the great scale, were reserved for individual contest, or for the lesser purposes of desultory warfare. The great object was to construct such stupendous bulwarks as might not only oppose the newly devised missiles, but, at the same time, support similar means of destroying the besieging army. Hence arose the formation of ramparts, and gradually, the necessity for deep ditches, and various outworks; by which considerable delay and difficulty might be created.

The fortifications of the fifteenth century, although to a certain extent new modelled, and made conformable to the necessity imposed by the invention and use of cannon, nevertheless did not display any ingenuity in regard to mutual defence. That great principle was little understood, and the minutiæ of the science remained, for a long time, miserably defective. Men of genius, at length, in part remedied the errors of the old school, and opened the way for that exactness of proportion, and for that systematic arrangement, which characterizes the works of modern times. The impregnable fortresses to be seen in various parts of Europe, cannot fail to transmit the names of their several engineers to posterity.

The immense armies now constantly brought into the field, and the heavy trains of artillery by which they are, in almost all cases, accompained, occasion not only an adequate preparation for resistance, but the necessity for establishing lines of communication, of depôts, &c., all of which must be on the best construction, for defence, containing safe lodgment for a sufficient garrison, together with ample and secure magazines for provisions and stores. Hence the province of the engineer becomes peculiarly important; it comprises various branches of information, and requires that readiness of computation, of discernment, and of appropriate resourse, which rarely combine in the same individual. The merely planning in the closet, and the laying down on the proper scite such defences as may perhaps be void of fault, so far as relates to mutual support, and to the great work of procrastination, will avail nothing, if the other essentials are neglected; and even when they are not, the whole may be rendered abortive, and become contemptible, merely from a want of judgment in point of locality.

Fortification is generally considered under two heads; *natural* and *artificial*. The former relates entirely to those situations which, being either completely inaccessible, or nearly so, require but few additions, and demand only such guards as may prevent surprise. For want of that precaution, some posts have been taken, which no army, however numerous and well provided, could have forced to a capitulation. Perhaps, of all the instances that could be adduced in regard to so fortunate a position as should defy every thing short of continued bombardment, the fortress of Ootradroog, situated in the dominions of the late Tippoo Saib, sultan of Mysore, may be justly considered as the most worthy of being cited. It stands on a plain, no hill or eminence of any importance being within several miles. It is, in fact, insulated, and consists of a solid rock, rising, on an average, about eight hundred feet above the adjacent level; its sides are nearly perpendicular throughout its whole circumference, which measures nearly a mile. The ascent to it is by stone steps, intermixed with occasional breaks for temporary ladders, the whole of which could be destroyed by the fall of a few large stones, always kept on the parapet for that purpose. Indeed, the interior is lined with such, they being admirably suited to the defence of so peculiar a station. There is no want of cannon on the works, which are ample, and were formed under the direction of a French engineer; they have plenty of water; ample stores were kept in immense excavations; and the most secure lodgment for a numerous garrison. Yet, as soon as the fall of Bangalore was ascertained, this important and almost impregnable fortress, to which, perhaps, there exists not a counterpart, surrendered to two battalions of Bengal sepoys.

It would be impossible to afford any instructions regarding those works which may be conjoined to natural defences, so as to render the whole complete: such must depend entirely on local circumstances, of which the skilful engineer will not fail to take advantage.

The term *artificial fortification* applies to every kind of defence, whether regular or irregular, pure or mixed; and has been divided by the most celebrated engineers into two distinct kinds, viz. *offensive* and *defensive*. The former relates principally to the various works used in attacks and sieges; the latter appertains to the more general purpose of securing towns, forming depôts, commanding important situations, defiles, &c., protecting harbours, and, in general, tending more to self-preservation, and to control, than to the annoyance of others, or to the extension of dominion.

This important science is again sub-divided into the *permanent* and the *temporary*: the former being with the view to endure the test of ages, while the latter is confined principally to operations in the field; and such works are, for the most part abandoned so soon as the occasion for their construction may have subsided.

Defensive fortification consists of three systems, each of which has its particular uses:

1. That which is usually adopted in the construction of works having four or five sides, or citadels, various small, or detached posts, horn-works, crown-works, &c., where the exterior of the defences, that is, between the salient angles of the two bastions, does not exceed 350 yards.

2. The next, which is of general use, and forms a very considerable portion of all regular fortifications, whose exterior sides of defence may be from 350 to about 400 yards.

3. The great, which is principally used where the exterior of the defences measures more than 380, and as far as 500 yards, or perhaps rather more; it is obvious, that very extensive fronts, even in a hexagon, or figure of six sides, would inclose an immense area; consequently would require a moderate army to man the defences. Hence we generally find this system composing only part of the works; such as are on the borders of a lake, or along the bank of a river; while the other sides are composed of the second, or mean system.

Such are the leading features and application of the three systems, as settled by the celebrated Vauban, and adopted by the most distinguished professors of our own time. Occasional deviations have, however, been made in several instances, with the approbation of military men; but, for the most part, such have

been with the view of conforming to local necessity, and of effecting a saving, either of materials, where they are scarce, or to disbursement, where that was an object.

We now come to the description of the several defences, as regulated by Vauban, and others of acknowledged military skill.

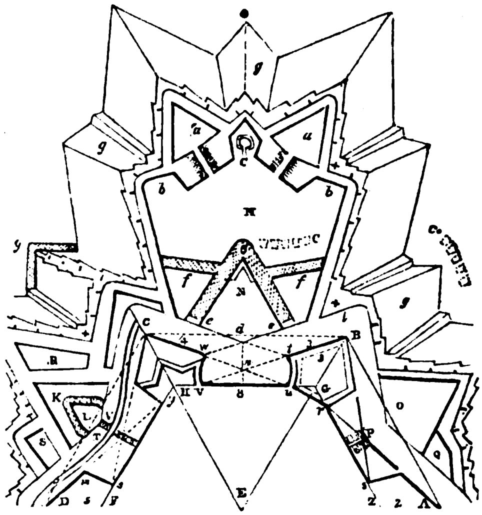
Fortifications may be considered as regular, when the inclosed area is of such a form as can be inscribed in some regular figure; such as a triangle, a rectangle, a circle, or an ellipsis; observing that such figure should, to a certain extent, suit itself to the town, &c., it is intended to protect.

It is usual to divide the perimeter, or whole outline of the figure, when it is either of the two latter forms, into as many faces, or portions, as may admit of suitable defences in either of the three systems already detailed. The number of faces must be regulated as well by the form, as by the extent of the figure. Small circles may be divided into five or six faces; moderately extensive ovals may have six also, while the more extensive circles and ovals will require an additional face or more, in order to reduce the exterior lines of defence within due bounds; so that every part of each face may be within musket-shot of those parts whereby it is flanked, or defended. Whenever this fundamental principle is disregarded, the plan will be proportionably weaker, according to the undue prolongation of the faces, and the consequent deficiency of mutual support.

The several fronts of a fortification may be all dissimilar, both in their proportions and in their extent; as also in the number and construction of their several outworks; yet the whole cannot be termed irregular. Thus the two ends of a long oval may be constructed on the second, or *mean* system; while each of the two long sides may be upon the third, or *great* system. One end may have a horn-work; the other a crown-work; the lateral faces being strengthened with ravelins, lunettes, tenailles, or other works. All these are evidently members of a perfect whole, and, when duly combined, according to the rules of art, form a complete and regular defence, founded on approved systems. Bergen-op-zoom affords one of the most striking instances on record of a purely artificial fortification; and as we have adduced one instance of a natural fortification in which but little of art was needed, this will form a valuable contrast. The fortification to which we have alluded is in reality a great earth work. It is almost level with the surrounding country, and resembles the engraving in the next column; but its masonry is protected by masses of earth, which deadens and destroys the effect of the balls.

When the number of faces has been adjusted and laid down, it is proper to decide whether the works are to be planned outwards, or inwards, from the line laid down. In the former case much space is gained by keeping all clear within that line, which, by this means, becomes the interior side: in the latter instance the line becomes the exterior side, all the works being raised within it, which considerably diminishes the area within them.

It is to be remembered, that in laying down the plan of a fortification, the several lines, describing the outer part of each rampart, exhibit the situation of a semicircular projection of masonry, called the cordon, which is, with few exceptions, made at the top of their respective facings of stone, brick, &c., called revetments. The line thus following the direction of the cordon, as it proceeds along the works, is called the principal.



A reference to the above engraving will illustrate the foregoing description. The half of a hexagon, or polygon of six equal sides, is selected, as being the most appropriate to this occasion. The line A D is the diameter of the circle; which circle having been divided into six equal parts, each equal to the radius, or semidiameter, A E, or E D, gives the faces formed by the passage of the rays B E and C E, through the points of equal division, B and C. Let us suppose the fortification to proceed inwards: in such case the lines A B, B C, C D, will be termed exterior sides, and all the principal will be formed within them; whereas, had it been intended to cover more ground, and to keep the whole of the area contained within the lines A B, B C, C D, and D C, clear, the principal would have been projected outwards, and the lines A B, B C, C D, would then have been termed the interior side. The former mode is in use when the exterior of the defences is first marked out, and has its separate mode of formation; and the latter is adopted where the interior of the works is established by any pre-existing circumstances, such as fortifying an old town, &c.; and proceeds on a suitable plan of projection. The two modes correspond perfectly, giving the same angles and proportions; the former on a diminished, the latter on an extended scale.

The interior lines, F G, G H, H I, form parallel faces with those on the exterior lines A B, B C, C D. If it were required to fortify outwards, they would be the bases of their several defences respectively, and the measurements would be taken from them, in lieu of from the exterior line. We shall proceed according to the latter mode, it being the most common and the most familiar.

To fortify inwards from an exterior line.—Let the exterior line B C be 180 toises (each toise being one fathom, or six feet); bisect it in *d*, and draw the perpendicular *d* 8, equal to one-sixth of the exterior line B C, namely, thirty toises. Now from B draw the line B *v*, passing through the point *n*; and from C draw the line C *u*, intersecting B *v* in *n*. Set off

fifty toises from the points B and C, on their respective lines, which are called the lines of defence, giving B *t* and C *w* for the faces of the two bastions. With the opening *t w*, measure *t v*, and *w u*, on the lines of defence, to determine their proper lengths, so as to give *u v* for the length and position of the curtain; next draw the lines *t v*, and *w u*, either curved or straight, for the flanks of the bastions. If they are to be curved, which are generally preferred, the points *t* and *w* will be the centres of equal circles, whereof the two flanks will be equal segments.

Proceed in the same manner with the other two fronts, A B and C D; you will thus complete two bastions, 3 and 4, and the halves of two more, 2 and 5. Next measure off fifteen toises, and draw something less than quadrants, or quarters of circles, from the points B and C; the centres of those quadrants being exactly opposite thereto, place your scale so that you may draw lines from the ends of the quadrants towards the shoulders of the bastions, but draw no farther than suffices to touch upon the perpendicular of thirty toises; thus your scale would give the direction *l w*, but your line would stop a little below *d*. This being done in both directions, and throughout the three faces, will give the width of the ditch, and the interior lines, or re-entering angles of the ravelins O, N, K. The body of the ravelin is formed by measuring ten toises on the face of each bastion, setting off from the shoulders *t w* towards the salient or projecting angles (there called flanked angles) B and C. An opening of the compasses equal to *u w* (or to *t v*), with the ten toises included, will give the distance of the salient angle, *o*, of the ravelin N, from the centre, 8, of the curtain *u v*. The sides, or faces, of the ravelin are determined by lines drawn from the salient angle to those points, on the faces of the bastions 3 and 4, already set off at ten toises each from their respective shoulders, *t* and *w*.

It should have been stated that all angles projecting outward from the body of the place, are called salient angles: for instance, *s*, B, *t*, of bastion 3, and *e*, *o*, *e*, of the ravelin N; while such angles as point inwards, towards the body of the place, are designated re-entering angles; such as *t*, *u*, *w*, on the lines of defence of the centre face. When an angle re-enters at such a position in the outworks that its apex, or point, cannot be seen, and consequently cannot be defended from the body of the place, it is called a dead angle. Such cannot easily take place where the smallest attention is paid to the most ordinary rules, but, wherever found, should be exploded from the defences, either by cutting off a large part of the pinch, or narrowest part, and substituting a curtain, or by new-modelling the defences in that part. It may be proper to observe, in this place, that works intended for mutual defence should never exceed an angle of 120°, nor be less than 60°. The medium, or 90°, which forms a right angle, generally considered, is indisputably the best for the above purposes. Where batteries stand at such an opening that their direct fire (that is, immediately to their own front) is parallel with the front of the part they flank, it is called a razant, or grazing fire; but when the angle is less than 90°, so that the direct fire would strike upon the face of the work to be defended, it is termed fishant: both have their uses, but the latter is rarely adopted, except from necessity, because a direct fire, at right angles, may be made to plonge, by giving the cannon an inclination more parallel with the side of the embrasure, which, being angular, allows a deviation of many degrees from the direct fire.

When two lines form a very acute angle with each other, they no longer are defences; for, in case the enemy should carry either of them, he would be able to work its battery against the other line; and though the fire would be plonging, and that too at a great disadvantage, yet, as many shots would light within the embrasures, the parapet would speedily be destroyed. The revetment, or masonry, in the front of the line so plonged, would not be much hurt, as it would turn off the shots.

Before we proceed farther, it is expedient that the reader should examine the line of the principal work, following along A, *o*, S, *r*, *s*, B, *t*, *u*, *v*, *w*, C, *b*, *y*, *s*, *m*, D, in all which he will perceive that every part is made to flank some other. The ravelins O, N, K, will be found to give great security to their several curtains, S, *r*, *u*, *v*, and *y s*; while at the same time they would enfilade whatever approaches might be made towards the salient angles of the bastions. In examining these circumstances, all the other outworks must be exempted from consideration: our view must be confined to the manner in which the gates in the curtains are protected; the flanks of the bastions concealed from every part but the line of their direct fire; and the spaces opposite the salient angles subjected to a heavy cross fire. The ravelins themselves stand at too wide an angle to absolutely flank each other, but they are capable of scouring the glacis reciprocally, and would, as before remarked, subject the besieger to a dangerous enfilade, or flanking fire, were he to proceed without due attention to their obnoxious positions. In works of more sides, where the angles of the bastions are necessarily more obtuse, the ravelins are thrown more towards a right angle with each other, and afford mutual support, even in cases of assault.

The communications with the ravelins are effected by the aid of bridges, when wet ditches are in question, as may be seen in the third face, *y s*, where the bridge V is carried over from the curtain to the counterscarp, or outer face of the ditch, so as to afford access to the ravelin K, in which is the intrenched redoubt L. The double lines, T, represent a channel of about fourteen feet broad, and about six or seven feet deep, made in all ditches that are at any time filled with water. These channels are called cunettes, or cuvettes; they are usually lined with masonry, and kept full, so as to prevent surprise: when the water is allowed to fill the whole ditch, which should generally be to the depth of nine or ten feet, or at all events so as not to be fordable, the cunette proves a formidable obstacle.

The bridges have barriers at their outer ends, and towards their inner ends generally a drawbridge, besides one that lifts immediately under the gateway, to which it gives additional strength. The very small compass allowed for the exhibiting of such figures as are indispensably necessary towards the right understanding of the subject, absolutely precludes the possibility of showing the dimensions of the ramparts, &c., and of necessity occasions the omission of many particulars in our engraving. In the common mode of building ramparts, with a revetment of masonry, the berm should be at least ten or twelve feet; and, where only turf facing is used, or that the soil with

which the rampart is filled, between the outer and inner faces of masonry, is of a loose nature, the berm should then be full twenty feet broad. The bulk of the rampart should, however, be considered; also whether it be much exposed or not; for on these points much will depend as to the probable quantity of battered rubbish to be sustained. There used to be a work, called the fausse-bray, carried all round the principal and the edge of the berm; its intention was to defend the ditch, and its fire was indeed highly destructive; but the facility with which it could be enfiladed (for it was necessarily low) evinced its inutility in general: the immense number of splinters falling from the rampart, immediately above, was another formidable objection. The fausse-braye is, therefore, out of repute; though in some fortifications a substantial parapet supplies its place, generally of masonry, more for the purpose of stopping the rubbish of a battered rampart than for that of sheltering troops. Perhaps the strong hedge adopted in many instances may be preferable: to say the least, it is far cheaper, and almost as useful.

The first drawbridge generally connects with the body of the bridge passing over the ditch, and is drawn up by persons standing on the brink; while that drawbridge, which rises close up against the gate, is so contrived as to bury itself, for at least its own thickness, into the masonry; while its edges are secured from the grazing of shots, ranging against the wall, and the possibility of wrenching the timber out of its place is sufficiently obviated. The gates usually close in the ordinary way; and over them a *portcullis* is sometimes suspended horizontally, its hinges being close behind the gates when shut. This immense machine resembles a very large harrow, and lets down, much like the ports of a ship, until it hangs vertically, close at the back of the gates, and, being secured with long iron stays, beams of wood, passing like window-bars into the wall, and other devices, it proves adequate to the repulsion of even a common sized petard. Some places have a succession of such gates and portcullises, one behind the other, which, added to the casemates being lined with defenders, renders it almost impossible to force these passages. When matters are driven to extremity, owing to the ravelin being possessed by the enemy, and by the defences on the curtain and flanks being raised, the gateways are filled up with rubbish, either loose or in bags, &c., so that they are no longer passable.

The unguarded point opposite the angle B, of bastion 3, is left purposely to show how easily a besieging army would effect a breach at that angle, provided no additional outworks were supplied; for, as yet, we are to consider the fortress to consist only of the principal and the ravelins. A suitable train of battering cannon brought to act upon the point B, while other batteries were employed to silence the faces of the adjacent ravelins O and N, would, in a very few days, effect a breach, and give the besiegers a command of the ditch, by establishing themselves in a lodgment on the crest of the glacis *g*, at the salient point Q; whence they would batter the flanks *o* S, and *w v*. Then, as nothing could oppose their passage over the ditch, which if wet would be passed by sap (that is to say, by filling up with fascines, &c.), the angle B would be carried by storm; for the matter would obviously rest on the numbers and on the personal prowess of the contending forces. The issue of such affairs have been so various, that it would be presumption to say the besiegers must succeed; but if the breach be practicable, and the internal state of the bastion as seen at No. 3, even though there should be an intrenchment of the gorge, from *r* to *u*, the chances would be in their favour after the breach was gained. This mode of defence is perhaps the best in hollow bastions (that is, in such as are not solid, but have deep areas within them level with the streets of the town, &c., called the terre-pleine); but in a solid bastion some defences should be internally constructed while the breach is making: of this some idea may be formed by the flanked angle in bastion 4, where a rampart and ditch are made, to force those who may ascend the breach to quit the bastion. The gorge may also be fortified as in bastion 3, whereby much time may be gained; a matter often of the utmost importance, either from expectation of succours, or to favour the evacuation of the fortress altogether.

In bastions No. 3 and 4, the flanks *t u*, and *w v*, are not only curved, but they are double, presenting of course two tiers of cannon, of which the upper stand on the bastion, while the lower are just below the level of the berm, whereof they constitute a part, and cannot be discovered beyond the crest of the glacis. These latter, therefore, cannot be battered from the approaches in the early stages of a siege; they lay, as it were perdue, in reserve for the defence of the ditch. There are two little semicircular projections at *t* and *w*, called orillons; these serve not only to cover the flanks *t u* and *w v* from enfilade, but each mounts a gun which cannot be perceived until half way over the bridge, and which serves to defend the gate when assaulted, as well as to take the assailants in flank and partly in reverse (i. e. from behind) as they advance to the attack. They are especially useful when a tenaille, as seen at P, is constructed in the dry ditch before the curtain S *r*; for when those who were placed in the tenailles which command the interior of the ravelin O, and of the redoubt Q, may be attacked in flank, and be obliged to retreat into the principal along the caponnaire P Δ, these guns pour in grape along the interior of the tenaille, when it is in the hands of the enemy, and enfilade so as to cause its abandonment.

The caponnaire is a passage made between two parapets, each having a long talus, or slope, outwards, as expressed by the small lines diverging from the path. It is commanded by (that is to say, open to the fire of) the flanks *o* S, and *s r*, and the centre of the curtain S *r*.

Having established, by this exposition, the absolute necessity for adding exteriorly to the defence of the principal, we shall now proceed to give a general insight into the various modes of constructing the other outworks; all being so designated which do not come within the principal, or body of the place. The reader should understand that every outwork, as it is placed more distant from the principal, must have a less elevation from the terre-pleine, or level of the area, on which the walls of the principal are founded. Thus we find, that a line drawn from the foot of the glacis *g*, at ⊕, opposite to the flanked angle of the bastion C, in the horn-work M, carried through the centre all the way up to *e*, which is the centre of the polygon, should graze the crests or inner summits of all the parapets standing in that line: this is called the defilement of the ramparts. By such a construction, it must be obvious that every work

added is a screen to, but is commanded by, that within it: thus, the bastion C, in the crown-work M, is a screen to the ravelin N, and that again to the curtain *u v*; while the intrenchments *f f* correspond in height with the flanks of the horn-work, so as to be under the command of the ravelin though they command all that portion of M which is in their front; and would continue to do so until the besiegers should construct batteries in the gorges of the bastions *b*, C *b*, or elsewhere, and render *f f* untenable.

The angle C, of bastion 4, is covered by the counterguard 7, which not only has that effect, but protects the adjacent tenaillon R, and can plonge upon the adjoining flank of the crown-work M. As a still farther covering to the bastion 4, a fleche, 9, is added, parallel to the counterguard, at the foot of its glacis, serving to render the attack more tedious and difficult, by compelling the besiegers to commence their approaches at a greater distance, where they are more generally subject to the fire of the bastions, &c., of the crown-work. The fleche, or arrow-head, should properly extend equally each way, having both faces alike, but that is not of any moment, and might have a second glacis; it is connected with the counterguard, or with the crown-work, or with the tenaillon, by means of a sortie, or winding passage cut through the glacis, or by a caponnier, as in the figure, intercepted with traverses, which will be duly explained when treating of the covert-way.

The ravelin K is defended within by the redoubt L, surrounded by a dry ditch. This redoubt should not be too high, because it would else serve to shelter the enemy in case they should succeed in silencing the faces of C *b*, and *m* D, of the corresponding bastions 4 and 5. The small work S is a lunette, which must be carried, or silenced, before the ravelin can be breached in that part; and, indeed, before any lodgment can be made opposite to the flanked angle D, of the bastion 5. The lunette must be lower than the ravelin, from which it properly derives its defilement, as will be hereafter explained.

The tenaillon is a very important conjunctive to the ravelin K; it, in fact, doubles its force on that side, and prolongs the battery of its other face; it flanks the counterguard, and its direct fire is a great protection to the demi-bastion *b*, on that side of the horn-work, as well as to the whole face of its ravelin *a*; it commands the fleche; and, being itself commanded by the ravelin K, and by the face C, and the counterguard, cannot be occupied by an enemy while any of these three works remain in force.

With respect to the construction of the counterguard, lunette, and tenaillon, they are not upon any exact scale in proportion to the principal, as the ravelin is; but, though not perfectly arbitrary, their formations depend on some general rules, which should invariably be had in view. The counterguard is always placed on the counterscarp, its front immediately behind the glacis, and its rear generally being a continuation of the revetment of the counterscarp, so that the passage lies along its terre-pleine, or battery. This kind of work may be of any extent; that is, it may proceed from ravelin to ravelin without interruption; or it may break off where it enters a lunette, a tenaillon, or a redoubt; or it may be only formed of two parallels equal in length with the faces of the bastion. On account of the number of men required for the defence of extensive outworks, counterguards are advantageously made hollow, having casemates covered with bomb-proofs, their parapets being solid masonry: their entrances, at each end, are secured by barriers and drawbridges; and their walls may, in places, be pierced with loop-holes, through which musketry may be discharged against assailants.

Casemates are likewise made on each side of posterns, or arched passages through the faces of ravelins; there are always drawbridges and barriers in such situations, as also at the cuts through the lunettes, &c., which lead through the covert-way to the esplanade, and are called sorties. The necessity for casemates must, generally, depend on the quantity and distance of outworks from the body of the place: it should be a rule never to place an outwork so that it could be cut off, without receiving aid from some sufficiently strong and contiguous part. Were this neglected, the enemy would not fail to surround such ill-judged detachments, and to a certainty carry them off during the night. Admitting this principle, the fleche 9 would be subject to the foregoing evil, if there were not a strong body of troops stationed in the counterguard, or the flank of the crown-work, from which detachments could be sent without delay.

Lunettes are generally constructed by producing their faces at about one-half the length of the ravelin, which they flank at right angles; their own flanks are drawn perpendicular to the face of the bastions which command them, generally falling about the middle of such face. Sometimes the lunette is separated, by a narrow fosse, from the body of the ravelin; in other instances, its face joins that of the ravelin, the fosse being arched over, and a battery placed on the arch, by which the ditch of the ravelin is scoured. The face of the lunette gives a direct fire towards the glacis, before the salient angle of the bastion 5.

Tenaillons are sometimes made on each side of a ravelin; and even beyond them a small detached ravelin, or a bonnet, is sometimes added. The rule for constructing a tenaillon is, to prolong the other face of the ravelin, thereby to make its front, and to determine the length of that front by a flank drawn perpendicular to the centre of the face of that bastion before which the tenaillon stands; as is seen in the tenaillon R, standing in front of the bastion 4, and covering the face of the ravelin K.

Redoubts standing in ravelins, being intended as a resort for the troops driven from the defences of its faces, and requiring great strength of defenders, should invariably be casemated throughout, in the most substantial manner; they may not only mount batteries on their ramparts, which should command those of the ravelins wherein they are placed, but they may be pierced below with abundance of loop-holes, and with embrasures for cannon, provided the ditch be of sufficient depth and width to prevent assault, and that the interior of the ravelin be, as it ought, perfectly level, and contain nothing to conceal the enemy: in each redoubt there should be a small expense magazine, and in every outwork one or more wells should be made, if practicable, of sufficient capacity to supply plenty of water.

Redoubts made to flank other works can have no fixed rule; they are generally placed to most advantage, and their fronts are always disposed towards those parts of the exterior which stand in need of

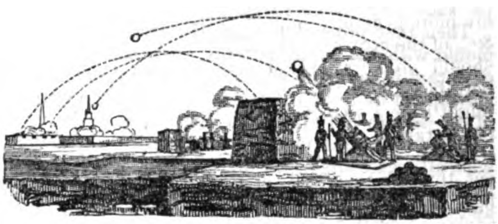
such support. In some places, as at Q, they are made more to cover a weak point, than with any immediate view to protracting the assault; the want of a redoubt, or some other work, on the other side of the bastion O, serves to prove the utility of that at Q; it being evident, that could an enemy's battery be placed anywhere about C *o*, that is, in a position to batter the bastion 3, the greater part of the defences of the principal would be subjected to mischief; and that, as the approaches should advance upon the glacis, the ravelins N and O would be in a measure cut off from all connection with the curtains S *r*, and *u v*. We suppose the crown-work M not to exist.

We now come to speak of the crown-work; it is a part of immense importance, and should be rendered as strong and efficient as possible. This kind of fortification is built on various accounts, viz., to occupy ground which, being left at the disposal of an enemy, might prove of considerable injury to the body of the place; to inclose buildings that could not be included within the principal; to defend a promontory, or a projection, covering a harbour; to prolong a line of works, and other causes which the locality may suggest. When, however, a piece of ground, which stands higher than could be commanded from the works of the principal, is to be occupied, a crown-work would be improper: in such case, a citadel is advantageously made on the superior ground; observing that, in lieu of a ravelin being at N, there would be a complete defensive face, appertaining to the citadel commanding the works of the fortress, which, instead of presenting defences along the centre B C, should rather lay open to the batteries of the citadel. These latter should command the whole interior of the polygon, and be well casemated throughout, for the safe lodgment of all the garrison, and for the safe keeping of provisions and stores, for six months at least. The instances on record of citadels holding out for a long time, should render their use more common, especially where the ground favours their command of all the other works.

Although we have, in tracing the defilement of the ramparts, from the point ⊕, to the centre of the polygon E, laid it down as a general rule, that the ascent of the works should assimilate to that line; yet, in such very spacious defences as crown-works sometimes are (for their area is occasionally equal to a third of that within the interior line of the polygon), some exceptions will take place; especially when the ravelins opposite to the faces of the crown-work are defended by still farther advanced outworks: then the angle of defilement would be so acute, from the terre-pleine, or horizon, as to cause scarce any difference between the heights of the ravelins, and of the bastions of the crown-work: a matter of obvious impropriety. Hence it is often necessary to give the ramparts of a crown-work rather more height than the line of defilement might allow; raising the ravelin and its intrenchments, and making cavaliers, as instanced in the bastion C, of the crown-work, on the solid bastions 3 and 4, so as to command the whole of the crown-work completely. A moineau, or flat bastion, of similar height with the cavaliers, may be made in the centre of the curtain *u v*, for the same purpose.

Cavaliers are of singular use on many other occasions, to which their form should be accommodated: that in the bastion *c* of the crown-work, is, from its shape, termed a horse-shoe; the flatness of its front is applicable to the situation it there holds, because it opposes a direct fire towards the point ⊕; but its circular tendency gives its front a bias towards the inner parts of the faces of the ravelins, while its flanks present a direct fire into the ravelins themselves, and give an oblique fire into the opposite ditches, whereby an assault of breaches in the salient angles of the demi-bastions *b b*, would become very hazardous.

We have already observed, that many outworks might be shown in addition to those given to the faces of the crown-work, such as lunettes, tenailles, tenaillons, fleches, advanced lunettes, redoubts, bonnets, &c.; but we apprehend the reader will, from the previous details, and the engraving to which they refer, be able to acquire a good general knowledge on the subject.



In the above engraving we give a view of the most destructive species of missile which has yet been brought to bear on regular fortifications. The mortar-battery, which is seen in operation, is usually placed near the rocket corps, and, when their labours are undisturbed, the most scientific fortifications are speedily demolished. An instance of this occurred at Antwerp, when the weight of the shells, and the destructive character of a newly-discovered rocket fire, in a few days accomplished what it would have taken months to effect by the ordinary means of offence.

Fossil. See Organic Remains.

Fothering; a peculiar method of stopping a leak in the bottom of a ship, while she is afloat, either at sea or at anchor, which is performed by fastening a sail at the four corners, letting it down under the ship's bottom, and then putting a quantity of chopped rope-yarn, oakum, wool, cotton, &c., between it and the ship's side.

Foundation, in *architecture*, is that part of a building which is under ground, and which Palladio makes as deep as one fourth part of the height of the whole building, unless there be cellars, when it may be somewhat lower.

Founder; an artist who casts metals in various forms, for different uses, as guns, bells, statues, &c.

Founder, in *sea language*. A ship is said to founder when, by an extraordinary leak, or by a great sea breaking in upon her, she is so filled with water, that she cannot be freed of it; so that she can neither veer nor steer, but lies like a log; and, not being able to swim along, will at last sink.

Foundery, or Foundry; the art of casting all sorts of metals into different forms. It likewise signifies the workshop, or smelting-house, in which these operations are performed. The sand used for casting is of a soft, yellowish, and clammy nature;

but it being necessary to strew charcoal-dust in the mould, it at length becomes of a black colour. This sand is worked over and over, on a board with a roller and a sort of knife; being placed over a trough to receive it, after it is by these means sufficiently prepared.

This done, they take a wooden board of a length and breadth proportional to the things to be cast, and putting a ledge round it they fill with sand, a little moistened to make it duly cohere. Then they take either wood or metal models of what they intend to cast, and, applying them to the mould, press them into the sand so as to leave their impression there. Along the middle of the mould is laid half a small brass cylinder, as the chief canal for the metal to run through, when melted, into the models or patterns; and from this chief canal are placed several others, which extend to each model or pattern placed in the frame. After this frame is finished, they take out the patterns, by first loosing them all round, that the sand may not give way.

Then they proceed to work the other half of the mould with the same patterns, in a similar frame, only that it has pins, which, entering into holes that correspond to it in the other, make the two cavities of the pattern fall exactly on each other.

The frame thus moulded is carried to the melter, who, after extending the canal of the counterpart, and adding the cross canals to the several models in both, and strewing dust over them, dries them in a kind of oven for that purpose.

Both parts of the mould being dry, they are joined together by means of the pins; and to prevent their giving way, by reason of the melted metal passing through the chief cylindrical canal, they are screwed or wedged in a sort of press.

While the moulds are thus preparing, the metal is fusing in a crucible, of a size proportionate to the quantity of metal intended to be cast.

Some of the founders' furnaces are like a smith's forge, others stand a few feet under ground, for the more easily and safely taking out a weighty pot of metal; which is done by means of circular tongs that grasp round the top of the crucible. When the metal is melted, the workman pours it through the chief canal of each mould, which conveys it to every distinct pattern.

When the moulds are cool, the frames are unscrewed, or unwedged, and the cast work taken out of the sand, which sand is worked over again for other castings.

Foundery of statues. The casting of statues depends on the due preparation of the pit, the core, the wax, the outer mould, the inferior furnace to melt off the wax, and the upper to fuse the metal. The pit is a hole dug in a dry place something deeper than the intended figure, and made according to the prominence of certain parts thereof. The inside of the pit is commonly lined with stone, or brick; or, when the figure is very large, they sometimes work on the ground, and raise a proper fence to resist the impulsion of the melted metal.

The inner mould, or core, is a rude mass to which is given the intended attitude and contours. Is is raised on an iron grate, strong enough to sustain it, and is strengthened within by several bars of iron. It is generally made either of potter's clay, mixed with hair and horse-dung, or of plaster of Paris mixed with brick-dust. The use of the core is to support the wax, the shell, and lessen the weight of the metal. The iron bars and the core are taken out of the brass figure through an aperture left in it for that purpose, which is soldered up afterwards. It is necessary to leave some of the iron bars of the core that contribute to the steadiness of the projecting part within the brass figure.

The wax is a representation of the intended statue. If it be a piece of sculpture, the wax should be all of the sculptor's own hand, who usually forms it on the core; though it may be modelled separately, in cavities moulded on a model, and afterwards arranged on the ribs of iron, filling the vacant space in the middle with liquid plaster and brick dust, whereby the inner core is proportioned as the sculptor carries on the wax.

When the wax, which is the intended thickness of the metal, is finished, they fill small waxen tubes perpendicular to it from top to bottom, to serve both as canals for the conveyance of the metal to all parts of the work, and as vent-holes to give a passage to the air, which would otherwise occasion great disorder when the hot metal came to encompass it.

The work being brought thus far, must be covered with its shell, which is a kind of crust laid over the wax, and which, being of a soft matter, easily receives the impression of every part, which is afterwards communicated to the metal upon its taking the place of the wax, between the shell and the mould. The matter of this outer mould is varied according as different layers are applied. The first is generally a composition of clay and old white crucibles well ground and sifted, and mixed up with water to the consistence of a colour fit for painting: accordingly they apply it with a pencil, laying it seven or eight times over, and letting it dry between whiles. For the second impression they add horse-dung and natural earth to the former composition. The third impression is only dung and earth. Lastly, the shell is finished by laying on several more impressions of this last matter, made very thick with the hand.

The shell, thus finished, is secured by several iron girts bound round it, at about half a foot distance from each other, and fastened at the bottom to the grate under the statue, and at top to a circle of iron where they all terminate.

If the statue be so large that it would not be easy to move the moulds with safety, they must be formed on the spot where it is to be cast. This is performed two ways: in the first, a square hole is dug under ground, much larger than the mould to be made therein, and its inside lined with walls of freestone or brick. At the bottom is made a hole of the same materials, with a kind of furnace, having its aperture outwards: in this a fire is made to dry the mould, and afterwards melt the wax. Over this furnace is placed the grate, and upon this the mould, &c., formed as above. Lastly, at one of the edges of the square pit is made another large furnace to melt the metal. In the other way, it is sufficient to work the mould above ground, but with the same precaution of a furnace and grate underneath. When finished, four walls are to be run around it, and a melting furnace prepared. For the rest, the method is the same in both. The mould being finished, and inclosed as described, whether under ground or above it, a moderate fire is lighted in the furnace under it, and the whole covered with planks, that the wax may melt gently down, and run out at pipes contrived for that

purpose, at the foot of the mould, which are afterwards exactly closed with earth, so soon as the wax is carried off. This done, the hole is filled up with bricks thrown in at random, and the fire in the furnace augmented till such time as both the bricks and mould become red hot. After this, the fire being extinguished and every thing cold again, they take out the bricks and fill up their places with earth, moistened and a little beaten, to the top of the mould, in order to make it the more firm and steady. These preparatory measures being duly taken, there remains nothing but to melt the metal, and run it into the mould. This is usually the office of a distinct workman. The furnace is commonly made in the form of an oven, with three apertures, one to put in the fuel, another for a vent, and a third to run the metal out at. From this last aperture, which is kept very close while the metal is in fusion, a small tube is laid, by which the metal is conveyed into a large earthen basin over the mould, into the bottom of which all the large branches of the jets or casts, which are to convey the metal into the various parts of the mould, are inserted.

These casts or jets are all terminated with plugs, which are kept close, that upon opening the furnace, the metal, which gushes out with violence, may not enter any of them till the basin be full enough of metal to run into them all at once: upon which occasion they pull out the plugs, which are long iron rods with a head at one end capable of filling the whole diameter of each tube. The whole of the furnace is opened with a long piece of iron fitted at the end of each pole, and the mould filled in an instant. This completes the work in relation to the casting part; the rest being the sculptor's or mason's business, who, taking the figure out of the mould and earth wherewith it is encompassed, saws off the jets with which it appears covered over, and repairs it with chisels, gravers, punches, &c.

Fount, or Font, in *typography;* a set of types, which includes running letters, large and small capitals, single letters, double letters, points, lines, numerals, &c.; as a fount of English, Pica, Bourgeois, &c. A fount of 100,000 characters, which is a common fount, would contain 5000 types of *a*, 3000 of *c*, 11,000 of *e*, 6000 of *i*, 3000 of *m*, and about 40 or 50 of *k*, *x*, and *z*. But this is only to be understood of the lower-case types, those of the upper case having other proportions, which we need not here enumerate.

Fountain, or Artificial Fountain, in *hydraulics;* a machine or contrivance by which water is violently spouted or darted up; called also a *jet d'eau*. There are various kinds of artificial fountains, but all formed by a pressure, of one sort or another, upon the water; viz. either the pressure or weight of a head of water, or the pressure arising from the spring and elasticity of the air, &c. When these are formed by the pressure of a head of water, or any other fluid of the same kind with the fountain or jet, then will this spout up nearly to the same height as that head, abating only a little for the resistance of the air, with that of the adjutage, &c., in the fluid rushing through; but, when the fountain is produced by any other force than the pressure of a column of the same fluid with itself, it will rise to such a height as is nearly equal to the altitude of a column of the same fluid, whose pressure is equal to the given force that produces the fountain.

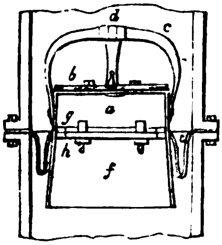
In Greece, every principal town had public fountains or conduits, some of which were of handsome design and of beautiful execution. In the city of Megara, in Achaia, there was a public fountain established by Theagenes, which was celebrated for its grandeur and magnificence. The *Pirene*, a fountain at Corinth, was encircled by an enclosure of white marble, which was sculptured into various grottoes, from which the water ran into a splendid basin of the same material. Another fountain in Corinth, which was called *Lerna*, was encircled by a beautiful portico, under which were seats for the public to sit upon during the extreme heats of summer, to enjoy the cool air from the falling waters. In the sacred wood of Æsculapius, at Epidaurus, there was a fountain that Pausanias cites as remarkable for the beauty of its decorations. At Messina there were also two elegant fountains, one called *Arsinoë*, and the other *Clepsydra*. Pausanias also alludes to several other fountains in various parts of Greece, celebrated for the grandeur and beauty of their architectural and sculptural decorations.

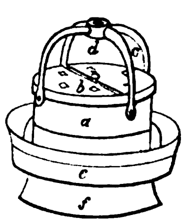
The ancient fondness for fountains still exists in Italy and the East. The French are celebrated for their fountains, but Italy, more particularly Rome, is still more so. The fountains of Paris and of the Tuileries, of the orangery at Versailles, at St. Cloud, and other places in the neighbourhood, are splendid structures. The principal and most admired fountains at or near Rome are those in front of St. Peter's, of the Villa Aldobrandini at Frascati, of the Termini, of Mount Janiculum, of the gardens of the Belvidere, in the Vatican, of the Villa Borghese, which has also in the audience chamber a splendid fountain of silver, five Roman palms in height, ornamented with superb vases and flowers; the fountains of Trevi, the three fountains of St. Paul, of the Acqua Acetosa, and many others described in the numerous works on that ancient city. Sir Henry Wotton describes, in his *Elements of Architecture*, a fountain by Michael Angelo, in the figure of a sturdy woman wringing a bundle of clothes, from whence the water issues that supplies the basin.

Fountain-Pump. This ingenious hydraulic machine is said to be the invention of Mr. Shalders. Bag-pumps on the same principle have, however, been used for many years. Mr. Shalders's pump has scarcely any friction, so that nearly the whole power of the person working the pump may be usefully employed in the elevation of water. Instead of being provided with a packed piston, moving up and down in a tube, the vacuum is formed by a leather chamber, which increases and diminishes in its dimensions according to the action of the pump lever. We give a wood-cut showing the general arrangement of its parts.

The pump cylinder is shown connected with its flange in the first figure. The bag and frame are raised by the stirrup *c d*, the valves being placed at *b*. In the external view of the piston, the cylinder to which the leather bag is attached is shown at *a*, and *c* represents that part of the leather by which it is attached to the pump-barrel. The bolts *g* and *h* show the mode by which the leather is held between the metallic flanges. The only inconvenience likely to result from working this pump will arise from the leather hardening when long out of use, which, in the summer season, would entirely destroy its usefulness. On ship-board, also, the same inconvenience would

be still more severely felt, as, in a long voyage, the pumps are sometimes but little resorted to, and on any sudden emergency it would not be practicable to new leather the bucket.





Fourteenth, in *music;* the octave, or replicate of the seventh; a distance comprehending thirteen diatonic intervals.

Fourth, in *music;* a distance comprising three diatonic intervals, or two tones and a half.

Fracture, in *surgery;* the separation of a bone by means of violence, into two or more fragments. A simple fracture is that where a bone is broken only in one part. A compound fracture is when two large bones, contiguous to each other, as the *ulna* and the *radius*, are both broken. A complicated fracture is that which is attended with a train of symptoms, as a wound or ulcer.

Fraction, in *arithmetic* and *algebra*, signifies a combination of numbers representing one or more parts of a unit or integer: thus four fifths is a fraction, formed by dividing a unit into five equal parts, and taking one part four times. Fractions are divided into *vulgar* and *decimal*. Vulgar fractions are expressed by two numbers with a line between them. The lower, the *denominator*, indicates into how many equal parts the unit is divided; and the number above the line, called the *numerator*, indicates how many of such parts are taken; as, in $\frac{7}{8}$, 8 is the denominator, 7 the numerator. Vulgar fractions have been divided, though not very accurately, into *proper, improper, simple, compound,* and *mixed,* viz:—A *proper fraction* is when the numerator is less than the denominator, as $\frac{3}{4}$, $\frac{3}{8}$, $\frac{7}{9}$, $\frac{9}{11}$, $\frac{101}{701}$, &c. An *improper fraction* is when the numerator is equal to or greater than the denominator, as $\frac{5}{5}$, $\frac{8}{4}$, $\frac{12}{12}$, $\frac{187}{8}$, &c. A *simple fraction* is that which consists of a single numerator and single denominator; and is either proper or improper, as $\frac{5}{7}$, $\frac{11}{7}$, $\frac{16}{81}$, &c. A *compound fraction* is a fraction consisting of two or more other fractions connected by the word *of;* thus $\frac{2}{3}$ of $\frac{3}{4}$, or $\frac{2}{3}$ of $\frac{7}{11}$ of $\frac{5}{8}$, &c., are compound fractions. A *complex fraction* is that whose numerator and denominator are both fractions; thus $\frac{\frac{3}{4}}{7\frac{1}{2}}$ is a complex fraction. These two distinctions, though frequently made by authors on arithmetic, are certainly improper, the former indicating an operation in multiplication, and the latter an operation in division. It is, therefore, improper to apply to them the denomination of *fractions*. An integer and fraction together is called a *mixed number;* that is, $7\frac{3}{4}$, $9\frac{1}{3}$, &c., are mixed numbers. The theory of vulgar fractions is one of the most important in algebra, but is rarely, we think, developed in a clear, simple, and easy manner in books on arithmetic. A correct understanding of them is of great importance for the proper prosecution of arithmetical and mathematical studies.—Decimal fractions include every fraction, the denominator of which is 10 or a power of it; as $\frac{6}{10}$, $\frac{7}{1000}$, &c.

Franc; a French silver coin, containing ten *decimes* and a hundred *centimes*.

Frankincense (called also *olibanum*, or simply *incense*) is a gum-resin, which distils from incisions made in the *boswellia thurifera*, a tree somewhat resembling the sumach, and belonging to the same natural family, inhabiting the mountains of India. It comes to us in semi-transparent, yellowish tears, or sometimes in masses, possesses a bitter and nauseous taste, and is capable of being pulverized. When chewed, it excites the saliva, and renders it white; and when burnt, it exhales a strong aromatic odour, on which account it was much employed in the ancient temples, and still continues to be used in Catholic churches. Formerly it was frequently administered medicinally, but myrrh and other similar articles have now taken its place. That which is brought from Arabia is more highly esteemed than the Indian.

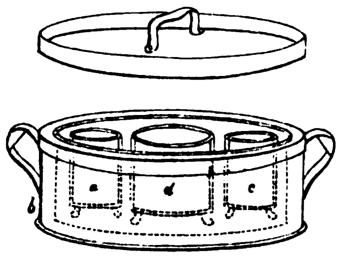
Freckles; small spots of a yellowish colour scattered over the face, neck, and hands. Freckles are either natural, or proceed accidentally from the jaundice, or the action of the sun upon the part. Heat, or a sudden change of the weather, will often cause the skin to appear of a darker colour than natural, and thereby produce what is called *tan, sunburn,* &c., which seem to differ only in degree, and usually disappear in winter. Persons of a fine complexion, and those whose hair is red, are the most subject to freckles, especially in those parts which they expose to the air.

The origin of freckles has been thus explained: in the spring, the skin, from the warm covering which the body has had in winter, and from various other causes, is peculiarly sensitive. The heat of the sunbeams now draws out drops of moisture, which do not dry as rapidly as in summer. These drops operate like a convex glass, to concentrate the rays, which are thus made to act powerfully on the *rete malpighii*, and the carbon which it contains is half acidified, and this substance, in this state, always has a dark colour. In the same manner arises the dark tint which the skin in general assumes in summer, and which fire communicates to artisans who labour constantly in its immediate vicinity. The only bad effect of freckles is, that they induce ladies to keep themselves shut up from the influences of the weather, or to apply injurious washes to the face to remove them.

Free Corps; a term used on the European continent for a corps which is organized to act merely till the end of the war, and consists of volunteers. It performs the service of light troops, and, as its losses are not heavily felt, is employed in all dangerous services, in harassing the enemy, &c.: on this account, more liberties are allowed to free corps than to regular troops. They are composed of persons of dubious characters, and there is always inconvenience, at the close of the war, in disbanding a numerous body of bold and active individuals, generally unfit for peaceful society. Napoleon employed none. Frederick the Great had some in his service, but, sensible of the danger of disbanding such desperadoes, at the close of the seven years' war, he, contrary to his promise, converted them into regular troops.

Freezing. The great sources of cold, and, as such, the production of ice by freezing, are rarefaction, evaporation, and chemical action. The operation of the first is scarcely felt in any but elastic fluids, as in those only can the volume be suddenly changed to any considerable extent. When a gas is rarefied, by removing pressure from it, its temperature always falls; and the more sudden the rarefaction is, so much greater is the cold produced. By allowing air, previously compressed, to expand suddenly, the temperature is reduced below 32°; and, by the condensed air being previously cooled, more intense cold is obtained.

The process of cooling by evaporation has been examined under Cold, and also the frigorific mixtures best fitted for freezing by chemical means. We now propose giving a diagram of a simple apparatus well fitted for carrying on the process of freezing, as well as that of keeping down the temperature of bodies already frozen.



This apparatus consists of an exterior and interior vessel of japanned iron, the interior vessel being one inch smaller than the inclosing case, *b*. In the interior case are placed detached vessels for containing the freezing mixtures.

When the apparatus is to be used with sulphate of soda and diluted sulphuric acid, it is advisable to prepare the acid the preceding day, in order that it may be of the same temperature as the surrounding air, when the experiment is to be performed. This being done, let two or three vessels, *a c d*, of about four ounces' capacity, be partly filled with diluted sulphuric acid, and placed in the middle of the internal vessel. They should then be surrounded by finely pulverized crystals of sulphate of soda, mixed with dilute acid, so as to fill the large internal vessel. The water or mercury should then be placed in the centre of the small vessels, the interstices being filled up with the sulphate of soda. The whole should then be covered up, and the process of freezing will speedily be accomplished.

Freezing Point denotes the point or degree of cold, shown by a mercurial thermometer, at which certain fluids begin to freeze, or, when frozen, at which they begin to thaw again. On Fahrenheit's thermometer this point is at + 32 for water, and at — 40 for quicksilver, these fluids freezing at those two points respectively. (See Thermometer.)

Freight is the consideration-money agreed to be paid for the use or hire of a ship, or, in a larger sense, the burden of such ship. The freight is most frequently determined for the whole voyage, without respect to time; sometimes it depends on time: in the former case it is either fixed at a certain sum for the whole cargo, or so much per ton, barrel, bulk, or other weight or measure, or so much per cent. on the value of the cargo. If a certain sum be agreed on for the freight of the ship, it must all be paid, although the ship, when measured, should prove smaller, unless the burden be warranted. If the ship be freighted for transporting cattle, at so much per head, and some of them die on the passage, freight is only due for such as are delivered alive; if for lading them, it is due for all put on board. When a whole ship is freighted, if the master suffer any goods besides those of the freight to be put on board, he is liable for damages. If the voyage be completed according to the agreement, without any accident, the master has a right to demand the freight before the delivery of the goods; but if such delivery is prevented by negligence, or accidents, the parties will be reciprocally responsible in the following manner: if the merchant should not load the ship within the time agreed on, the master may engage with another, and recover damages. If the merchant recal the ship after she is laden and sailed, he must pay the whole freight; but if he unload before the ship has actually sailed, he will in such case only be responsible for damages. If the merchant load goods which are not lawful to export, and the ship be prevented from proceeding on that account, he must nevertheless pay the freight. If the master be not ready to proceed on the voyage at the time stipulated, the merchant may load the whole or part of the cargo on board another ship, and recover damages; but any real casualties will release the master from all damages. If an embargo be laid on the ship before she sail, the charter-party is dissolved, and the merchant pays the expenses of loading and unloading; but if the embargo be only for a short limited time, the voyage shall be performed when it expires, and neither party is liable for damages. If the master sail to any other port than that agreed on, without necessity, he must sail to the port agreed on at his own expense, and is also liable for any damages in consequence thereof. If a ship be taken by the enemy, and retaken or ransomed, the charter-party continues in force. If the master transfer the goods from his own ship to another, without necessity, and they perish, he is responsible for the full value, and all charges; but if his own ship be in imminent danger, the goods may be put on board another ship, at the risk of the owner. If a ship be freighted out and home, and a sum agreed on for the whole voyage, nothing becomes due until the return of such ship. If the goods be damaged without fault of the ship or master, the owner is not obliged to receive them and pay the freight; but he must either receive or abandon the whole; he cannot receive those that are not damaged and reject the others. If the goods be damaged through the insufficiency of the ship, the master is liable for the same; but if it be owing to stress of weather, he is not accountable. If part of the goods be thrown overboard, or taken by the enemy, the part delivered pays freight. The master is accountable for all the goods received on board by himself and mariners, unless they perish by act of God, or the king's enemies. The master is not liable for leakage of liquors, nor accountable for contents of packages, unless packed in his presence.

Fresco Painting; that kind of painting which is executed with water-colours, upon a layer of fresh plaster, from which circumstance it derives its name. As great rapidity of execution is necessary to paint before the plaster becomes dry, cartoons are used for tracing the outlines of the figures, &c., and a small picture serves as a guide for the colours, if the cartoon does not indicate them. A great knowledge of colours and great skill in drawing are necessary for fresco painting, because there is no opportunity for

correcting: whatever the painter does is finished. The colours are mixed beforehand, and put on just as they are wanted; only in the dark parts a little retouching takes place. Fresco painting is one of the most durable kinds. It is pretended, that there are specimens of it extant of the time of Constantine the Great.

This art began to revive in the 16th century. The example of Michael Angelo and Raphael shows how worthy it is of the greatest artists. The painter cannot seduce the senses by soft tints and tender harmony of colours; he is, therefore, obliged to depend solely on form, character, and expression. If oil painting is better suited for nice expressions of the slightest emotions of the heart, fresco painting is the field which the true poet-painter will prefer. What can be more sublime than the Last Judgment of Michael Angelo, in the *Capella Sistina!* How rich and vast are Raphael's conceptions in the *Logyie Vaticano!* The Germans possess at present the most distinguished fresco painters, and Cornelius has established his fame by his grand fresco pictures in the *Glyptotheca* in Munich. Schnorr is also distinguished in this line, and the *Villa Massimi*, near Rome, is a fine monument of contemporary German art, as Overbeck, Schnorr, and Feith painted the three rooms in fresco. Fresco painting was long disregarded, when all noble and grand conceptions seemed to have fled from the art; and it is only in recent times that it has been taken up again, chiefly by the Germans.

Frets; certain short pieces of wire fixed on the finger-board of guitars, &c., at right angles to the strings, and which, as the strings are brought into contact with them by the pressure of the fingers, serve to vary and determine the pitch of the tones. The frets are always placed at such distances from each other, that the string which touches any particular fret is one semitone higher than if pressed on the next fret towards the head of the instrument, and one semitone lower than when brought into contact with the next fret towards the bridge. Formerly, these frets, or stops, consisted of strings tied round the neck of the instrument.

Friction; the act of rubbing two bodies together, or the resistance in machines caused by the motion of the different parts against each other. Friction arises from the roughness of the surface of the body moved on, and that of the moving body; for such surfaces consisting alternately of small eminences and cavities, these act against each other, and prevent the free motion that would ensue on a supposition of the two bodies being perfectly polished planes.

Ferguson found that the quantity of friction was always proportional to the weight of the rubbing body, and not to the quantity of surface: and that it increased with an increase of velocity, but was not proportional to the augmentation of celerity. He found also, that the friction of smooth soft wood, moving upon smooth soft wood, was equal to one third of the weight; of rough wood upon rough wood, one half of the weight; of soft wood upon hard, or hard upon soft, one fifth of the weight; of polished steel upon polished steel or pewter, one quarter of the weight; of polished steel upon copper, one fifth, and of polished steel upon brass, one sixth of the weight.

Coulomb made numerous experiments upon friction, and, by employing large bodies and ponderous weights, and conducting his experiments on a large scale, corrected several errors, which necessarily arose from the limited experiments of preceding writers. He brought to light many new and striking phenomena, and confirmed others, which were previously but partially established.

We cannot, in a work of this description, follow M. Coulomb through his numerous and varied experiments; all that can be expected will be a short abstract of the most interesting of his results; a few of which are as follows:—1. The friction of homogeneous bodies, or bodies of the same kind, moving upon each other, is generally supposed to be greater than that of heterogeneous bodies; but Coulomb showed that there are exceptions to this rule. 2. It was generally supposed that, in the case of wood, the friction is greatest when the bodies are drawn contrary to the course of their fibres; but Coulomb showed, that the friction in this case is sometimes the smallest. 3. The longer the rubbing surfaces remain in contact, the greater is their friction. 4. Friction is in general proportional to the force with which the rubbing surfaces are pressed together, and is commonly equal to between one half and one quarter of that force. 5. Friction is not generally increased by augmenting the rubbing surfaces. 6. Friction is not increased by an increase of velocity; at least it is not generally so; and, in some cases, even decreases with an increase of celerity. 7. The friction of cylinders, rolling upon a horizontal plane, is in the direct ratio of their weights, and in the inverse ratio of their diameters.

An easy method of experimenting on the friction of surfaces, is, to place a plank with its upper surface level, and on this a thin block of the matter to be tried, with a cord fixed to it, which block may be loaded with different weights; and a spring steelyard attached to the other end of the cord, to draw it along by, will show the force necessary to produce motion. It appears from experiments, that the friction of different combinations of matter differs very considerably, and that an immense quantity of power may be lost in a machine by using those substances for the rubbing parts which have great friction. In a combination where gun-metal moves against steel, the same weight may be moved with a force of 15½ pounds, which it would require 22 pounds to move when cast-iron moves against steel. The resistance called *friction* performs important offices in nature and in works of art. Friction destroys, but never generates motion.

D. Palcani made some interesting experiments on the means long known for obtaining fire by the friction of two pieces of wood. He gave to one of these rubbing pieces the form of a tablet; and to the other, that of a spindle, or cylinder: the result of these experiments will be sufficient to show, that, in the construction of machines and instruments, some attention should be paid to the wood destined to be exposed to mutual friction.

Cylinder.	Tablet.	Duration.	Effect.
Box-wood	Box	5 minutes	Sensible heat
Ditto	Poplar	Ditto	Ditto
Ditto	Oak	Ditto	Ditto
Ditto	Mulberry	3 minutes	Considerable heat and smoke
Ditto	Laurel	Ditto	Ditto
Laurel	Poplar	2 minutes	Ditto
Ditto	Ivy	Ditto	Ditto

Cylinder.	Tablet.	Duration.	Effect.
Ivy	Box	3 minutes	Considerable heat and smoke
Ditto	Walnut	Ditto	Ditto
Olive	Olive	Ditto	Ditto
Mulberry	Laurel	2 minutes	Considerable heat, smoke & blackness
Ash	Oak	5 minutes	Sensible heat
Ditto	Fir	Ditto	Ditto
Pear-tree	Oak	Ditto	Ditto
Cherry	Elm	Ditto	Ditto
Plumb	Apple-tree	Ditto	Ditto
Oak	Fir	Ditto	Ditto

By changing the experiment and rubbing a cylinder of one of the kinds of wood between two tablets of the other, a cylinder of poplar for example, between two tablets of mulberry-wood, the increased surfaces which were in contact with the air, produced a heat much more considerable, and almost the whole of the woods above enumerated took fire.

In large machines where there is much friction, heating may be prevented by continually directing a current of cold water on the rubbing surfaces; in common machines, carriages, &c., this is diminished by the use of an unctuous matter. Many instances are recorded, where, during the great heats of summer, carriages and other machines exposed to violent motion, have inflamed because care has not been taken to grease them: this was the occasion of a conflagration in the mills on the Surrey side of Blackfriar's Bridge, through which they were consumed. It is to be remarked that, if grease is permitted to harden upon rubbing surfaces, instead of lessening the friction, it increases it; and, as this covering is highly inflammable, it renders spontaneous inflammation more easy. In many cases, therefore, it is preferable to rub the machinery with soap, talc, plumbago, or some other such substance, which, without being oily, is unctuous to the touch.

Were there no friction, all bodies on the surface of the earth would be clashing against one another; rivers would dash with unbounded velocity, and we should see little besides collision and motion. At present, whenever a body acquires a great velocity, it soon loses it by friction against the surface of the earth; the friction of water against the surfaces it runs over soon reduces the rapid torrent to a gentle stream; the fury of the tempest is lessened by the friction of the air on the face of the earth; and the violence of the ocean is subdued by the attrition of its own waters. Its offices in works of art are equally important. Our garments owe their strength to friction; and the strength of ropes, sails, and various other things, depends on the same cause; for they are made of short fibres, pressed together by twisting; and this pressure causes a sufficient degree of friction to prevent the fibres sliding one upon another. Without friction, it would be impossible to make a rope of the fibres of hemp, or a sheet of the fibres of flax; neither could the short fibres of cotton have ever been made into such an infinite variety of forms as they have received from the hands of ingenious workmen. Wool also has been converted into a thousand textures for comfort or for luxury; and all these are constituted of fibres united by friction. In fine, if friction retards the motion of machines, and consumes a large quantity of moving power, we have a full compensation in the numerous and important benefits which it insures to us.

Friction, in *medicine* and *surgery;* the act of rubbing the surface of the body, whether with the hand only, with the flesh-brush, flannel, or other substances, or with oils, ointments, or other medicinal matters, with a view to the preservation of health, or to the removal of particular diseases. The wholesome effects of friction are well illustrated by the advantages of currying horses. Friction is an efficacious remedy in several conditions of disease; particularly in chronic rheumatisms of long standing; in muscular contractions, succeeding to rheumatism, &c., and connected often with effusions of lymph; in some states of paralysis; in certain indolent tumours, &c. In these cases, a variety of unguents and liniments is recommended; but the friction itself is the principal source of relief.

FRIEZE, in *architecture;* that part of the entablature of columns between the architrave and cornice. Anciently friezes were enriched with figures of animals; in modern times they are commonly ornamented by figures in bassi relievo.

FRIGATE, in *naval affairs;* a light vessel, now frequently prepared by cutting down larger ships of war.

FRONTAL, in *anatomy;* an epithet for what belongs to the forehead, as the *frontal bone*, and the *frontal sinus*.

FRONTALIS; the name of a muscle of the forehead, which serves to contract the eyebrows.

FRONTIS, OS; one of the bones of the skull, which joins the bones of the sinciput and temples, by the coronal suture.

FRONTIGNAC; a sweet muscatel wine, which is made at Frontignan, in Lower Languedoc, and is carried to Cette and Montpelier. There are two kinds, the red and the white. Epicures use it with some kinds of fish.

FROST is the name we give to that state of our atmosphere in which water is changed into ice. The degree of temperature at which this takes place, is called the *freezing point*. The cold air draws from water the portion of caloric which is necessary for its existence in a fluid state. The power of frost is immense; a freezing liquid will burst the strongest vessels in which it is enclosed. Organic bodies do not suffer so much from it, and many are entirely unhurt by it. Severe frosts are not so injurious to plants, after dry weather, as when they follow immediately after rain or a thaw. The cause of this probably is, that in damp weather, even in winter, the tender vessels of plants are filled with sap, which, expanding into ice at the time of the frost, breaks them, and thus injures their whole internal organization. From the same cause, the strongest oaks split in a severe frost; which is also dangerous, and sometimes fatal to men and animals. It appears wholly to destroy the irritability of the bodily frame, and to rob it of its internal heat. A person feels an irresistible inclination to sleep; he yields, though against his will, and, while lost in insensibility, his limbs begin to stiffen. If a man thus asleep be brought into a warm room, the sudden passage from cold to warmth causes his death; but if he be rubbed in the snow, he may often recover. The same is the case with regard to the frozen limbs of men and animals, which can only be saved by being gradually thawed, especially in snow.

Frost is also very injurious to certain kinds of food. All watery fruits are deprived by frost of their pleasant taste and their nourishing properties, and soon grow rotten after being thawed. Even meat, which appears to be preserved from tainting by the frost, corrupts soon after thawing. Liquids, as beer, for instance, lose their good taste. Violent winds always diminish the coldness of the air. Many fluids expand by frost, as water, which expands about one tenth part, for which reason ice floats in water; but others, again, contract, as quicksilver, and thence frozen quicksilver sinks in the fluid metal.

Frost, being produced by contact with the atmosphere, naturally proceeds from the external parts of bodies inwards: so, the longer a frost is continued, the thicker the ice becomes upon the water in ponds, and the deeper into the earth is the ground frozen. In about sixteen or seventeen days' frost, Mr. Boyle found it had penetrated fourteen inches into the ground. At Moscow, in a hard season, the frost will penetrate two feet deep into the ground; and Captain James found it penetrated ten feet deep in Charlton Island; and the water in the same island was frozen to the depth of six feet. Scheffer assures us, that, in Sweden, the frost pierces two cubits, or Swedish ells, into the earth, and turns what moisture is found there into a whitish substance, like ice, and penetrates standing water to three ells or more. The same author also mentions sudden cracks or rifts in the ice of the lakes of Sweden, nine or ten feet deep, and many leagues long, the rupture being made with a noise not less loud than if many guns were discharged together. By such means, however, the fishes are furnished with air, so that they are rarely found dead. The natural history of frosts furnishes very extraordinary results. The trees are often scorched and burnt up, as with the most excessive heat, in consequence of the separation of water from the air, which is therefore very drying. In the great frost in 1683, the trunks of oak, ash, walnut, &c., were split and cleft asunder, so that they might be seen through, and the cracks were often attended with dreadful noises, like the explosion of fire-arms. The close of the year 1708, and the beginning of 1709, were remarkable throughout the greatest part of Europe, for a severe frost. Doctor Derham says it was the greatest in degree, if not the most universal, in the memory of man; extending through most parts of Europe, though scarcely felt in Scotland or Ireland. In very cold countries, meat may be preserved by the frost six or seven months, and proves tolerably good eating. In those climates the frost seems never out of the ground, it having been found hard frozen in the two summer months. Brandy and spirit set out in the open air freeze to solid ice in three or four hours. Lakes and standing waters, not above ten or twelve feet deep, are frozen to the ground in winter, and all their fish perish. But in rivers, where the current is strong, the ice does not reach so deep, and the fish are preserved.—Hoar frost is the dew frozen or congealed early in cold mornings; chiefly in autumn.

We have collected some of the most remarkable instances of intense frost, and placed them in chronological order:

A.D.

223 Frost in Great Britain, which lasted five months.
250 The Thames frozen for nine weeks.
291 Almost every river in Britain frozen over for six weeks.
359 Severe frost in Scotland, which lasted for fourteen weeks.
508 The rivers in Britain all frozen over.
558 The Danube quite frozen over.
695 The Thames frozen for six weeks, and booths built on it.
759 Frost from October 1, till February 26, 760.
827 Frost in England for nine weeks.
859 Carriages used on the Adriatic Sea.
908 Nearly every river in England frozen over for two months.
923 The Thames frozen over for thirteen weeks.
987 Frost lasted 120 days, began December 22d.
998 The Thames frozen over for five weeks.
1035 Severe frost on June 24. All the corn and fruits destroyed.
1063 Thames frozen for fourteen weeks.
1096 Frost in England from November till April.
1114 Several wooden bridges carried away by ice.
1407 Frost, which lasted for fifteen weeks.
1434 From November 24, till February 10, the Thames frozen down to Gravesend.
1683 Frost of thirteen weeks.
1708-9 Severe frost for many weeks.
1715 The same for many weeks.
1739 Frost for nine weeks, began December 24.
1742 Severe frost for thirteen weeks.
1747 Severe frost in Russia.
1751 Severe frost many weeks in England.
1760 Severe frost in Germany.
1788 The Thames frozen below London bridge, and booths on it.
1794 Hard frost for many weeks, thermometer in London mostly at 20° below 0° of Fahrenheit.
1813-14 A frost for thirteen weeks, the Thames frozen over, and a fair kept on it.

FRUITFULNESS; the power of abundant production. This power exists in some organic beings in an incredible degree: in a poppy, 32,000 seeds have been counted. The elm produces annually 100,000 seeds. How numerous is the annual production of seeds from fruit-trees, &c.! As each of these seeds is capable of becoming an individual of the same sort, if each of them grew up, the whole surface of the earth would soon be covered with these trees. In the lower classes of animals, the fruitfulness is no less great: the queen-bee lays every year 5000 or 6000 eggs. The vast swarms of locusts, which sometimes lay waste immense tracts of cultivated country in Asia and Africa, and the caterpillars which are often so numerous in our own land, justify us in attributing to them the greatest fruitfulness.

The smallest herring has 10,000 eggs. A carp which weighs only half a pound, has 100,000, a larger one, 262,280; a perch, 324,640. The spawn of the sturgeon is calculated to contain 7,653,200 eggs. In the cod-fish, the number of eggs is reckoned at 9,344,000. In the higher classes of animals, there is less of fruitfulness; yet even in men it is greater than the mortality. In the last case, however, much depends upon climate, season, food, habits, manners, temperament, &c.

FRUSTUM, in *mathematics*; a part of some solid body separated from the rest. The frustum of a cone is the part that remains when the top is cut off

by a plane parallel to the base, and is otherwise called a *truncated cone*. The frustum of a pyramid is also what remains, after the top is cut off by a plane parallel to its base.

FUEL. Doctor Black divides fuels into five classes. The first comprehends the fluid inflammable bodies; the second, peat or turf; the third, charcoal of wood; the fourth, pit-coal charred; and the fifth, wood, or pit-coal, in a crude state, and capable of yielding a copious and bright flame. The fluid inflammables are considered as distinct from the solid, on this account, that they are capable of burning upon a wick, and become in this way the most manageable sources of heat; though, on account of their price, they are never employed for producing it in great quantities, and are only used when a gentle degree or a small quantity of heat is sufficient. The species which belong to this class are alcohol and different oils. The first of these, alcohol, when pure and free of water, is as convenient and manageable a fuel for producing moderate or gentle heats as can be desired. Its flame is perfectly clean, and free from any kind of soot; it can easily be made to burn slower or faster, and to produce less or more heat, by changing the size or number of the wicks upon which it burns; for as long as these are fed with spirit, in a proper manner, they continue to yield flame of precisely the same strength.

The cotton, or other materials, of which the wick is composed, is not scorched or consumed in the least, because the spirit with which it is constantly soaked is incapable of becoming hotter than 174° Fahrenheit, which is considerably below the heat of boiling water. It is only the vapour that arises from it which is hotter, and this too, only in its outer parts, that are most remote from the wick, and where only the combustion is going on, in consequence of communication and contact with the air. At the same time, as the alcohol is totally volatile, it does not leave any fixed matter, which by being accumulated on the wick, might render it foul, and fill up its pores. The wick, therefore, continues to imbibe the spirit as freely, after some time, as it did at the first. These are the qualities of alcohol as a fuel. But these qualities belong only to a spirit that is very pure. If it be weak, and contain water, the water does not evaporate so fast from the wick as the more spirituous part; and the wick becomes, after some time, so much soaked with water, that it does not imbibe the spirit properly. The flame becomes much weaker, or is altogether extinguished. When alcohol is used as a fuel, therefore, it ought to be made as strong, or free from water, as possible.

Oil, although fluid like spirit of wine, and capable of burning in a similar manner, is not so convenient in many respects. It is disposed to emit soot; and this, applying itself to the bottom of the vessel exposed to it, and increasing in thickness, forms by degrees a soft and spongy medium, through which heat is not so freely and quickly transmitted. It is true we can prevent this entirely by using very small wicks, and increasing the number, if necessary, to produce the heat required. Or we may employ one of those lamps, in which a stream of air is allowed to rise through the middle of the flame, or to pass over its surface with such velocity as to produce a more complete inflammation than ordinary. But we shall be as much embarrassed in another way; for the oils commonly used, being capable of assuming a heat greatly above that of common water, scorch and burn the wick, and change its texture, so that it does not imbibe the oil so fast as before.

Some have attempted a remedy, by making the wick of incombustible materials, as asbestos or wire; but still, as the oil does not totally evaporate, but leaves a small quantity of gross, fixed, carbonaceous matter, this, constantly accumulating, clogs the wick to such a degree, that the oil cannot ascend, the flame becomes weaker, and in some cases is entirely extinguished. There is, however, a difference among the different oils in this respect, some being more volatile than others. But the best are troublesome in this way, and the only remedy is, to change the wicks often, though we can hardly do this and be sure of keeping always an equal flame.

The second kind of fuel mentioned, peat, is so spongy, that, compared with the more solid fuels, it is unfit to be employed for producing very strong heats It is too bulky for this; we cannot put into a furnace, at a time, a quantity that corresponds with the quick consumption that must necessarily go on when the heat is violent. There is, no doubt, a great difference in this respect among different kinds of this fuel; but this is the general character of it. However, when we desire to produce and keep up, by means of cheap fuel, an extremely mild, gentle heat, we can hardly use any thing better than peat. But it is best to have it previously charred, that is, scorched, or burnt to black coal. The advantages gained by charring are considerable. When it is prepared for use in that manner, it is capable of being made to burn more slowly and gently, or will bear, without being extinguished altogether, a greater diminution of the quantity of air with which it is supplied, than any other of the solid fuels.

The next fuel in order is the charcoal of wood. This is prepared by piling up billets of wood into a pyramidal heap, with several spiracles, or flues, formed through the pile. Chips and brushwood are put into those below, and the whole is so constructed as to kindle throughout in a very short time. It would burst out into a blaze, and be quickly consumed to ashes, were it not covered all over with earth or clay, beaten close, leaving openings at all the spiracles. These are carefully watched; and whenever the white, watery smoke is observed to be succeeded by thin, blue, and transparent smoke, the hole is immediately stopped; this being the indication of all the watery vapour being gone, and the burning of the true coaly matter commencing. Thus is a pretty strong red heat raised through the whole mass, and all the volatile matters are dissipated by it, and nothing now remains but the charcoal. The holes being all stopped in succession, as this change of the smoke is observed, the fire goes out for want of air. The pile is now allowed to cool. This requires many days; for, charcoal being a very bad conductor of heat, the pile long remains red hot in the centre, and if opened in this state, would instantly burn with fury. Small quantities may be procured at any time, by burning wood in close vessels. Little pieces may be very finely prepared at any time, by plunging the wood into lead melted and red hot. This kind of fuel is very much used by chemists, and has many good properties. It kindles quickly, emits few watery or other vapours while burning, and, when consumed, leaves few ashes,

and those very light. They are, therefore easily blown away, so that the fire continues open, or pervious to the current of air which must pass through it to keep it burning. This sort of fuel, too, is capable of producing as intense a heat as can be obtained by any; but in violent heats it is quickly consumed, and needs to be frequently supplied.

Fossil coals charred, called *cinders*, or *coke*, have in many respects, the same properties as charcoal of wood; as kindling more readily in furnaces than when they are not charred, and not emitting watery or other gross smoke while they burn. This sort of charcoal is even greatly superior to the other in some properties. It is a much stronger fuel, or contains the combustible matter in greater quantity, or in a more condensed state. It is, therefore, consumed much more slowly on all occasions, and particularly when employed for producing intense melting heats. The only inconveniences that attend it are, that, as it consumes, it leaves much more ashes than the other, and these much heavier too, which are therefore liable to collect in such quantity as to obstruct the free passage of air through the fire; and, farther, that when the heat is very intense, these ashes are disposed to melt or vitrify into a tenacious, drossy substance, which clogs the grate, the sides of the furnace, and the vessels. This last inconvenience is only troublesome, however, when the heat required is very intense. In ordinary heat, the ashes do not melt, and though they are more copious and heavy than those of charcoal of wood, they seldom choke up the fire considerably, unless the bars of the grate be too close together. This fuel, therefore, is preferable in most cases to the charcoal of wood, on account of its burning much longer, or giving much more heat before it is consumed.

The heat produced by equal quantities, by weight, of pit-coal, wood-charcoal, and wood itself, is nearly in the proportion of 5, 4, and 3. The reason why both these kinds of charcoal are preferred, on most occasions, in experimental chemistry, to the crude wood, or fossil coal, from which they are produced, is, that the crude fuels are deprived, by charring, of a considerable quantity of water, and some other volatile principles, which are evaporated during the process of charring, in the form of sooty smoke or flame. These volatile parts, while they remain in the fuel, make it unfit (or less fit) for many purposes in chemistry. For, besides obstructing the vents with sooty matter, they require much heat to evaporate them; and therefore the heat of the furnace in which they are burnt, is much diminished and wasted by every addition of fresh fuel, until the fresh fuel is completely inflamed, and restores the heat to its former strength. But these great and sudden variations of the heat of a furnace are quite inconvenient in most chemical processes. In the greater number of chemical operations, therefore, it is much more convenient to use charred fuel, than the same fuel in its natural state.

It is proper to be on our guard against the dangerous nature of the burnt air which arises from charcoal of all kinds. Charcoal burns without visible smoke. The air arising from it appears to the eye as pure and as clear as common air. Hence it is much used by those persons who are studious of neatness and cleanliness in their apartments. But this very circumstance should make us more watchful against its effects, which may prove dangerous in the highest degree, before we are aware of it. The air arising from common crude fuel is, no doubt, as bad, but the smoke renders it disagreeable before it becomes dangerous. The first sensation is a slight sense of weakness: the limbs seem to require a little attention, to prevent falling. A slight giddiness succeeds, accompanied by a feeling of a flush or glow in the face and neck. Soon after, the person becomes drowsy, would sit down, but commonly falls on the floor, insensible of all about him, and breathes strong, snoring as in an apoplexy. If the person is alarmed in time, and escapes into the open air, he is commonly seized with a violent headache, which gradually abates. But when the effect is completed, as above described, death very soon ensues, unless relief be obtained. There is usually a foaming at the mouth, a great flush or suffusion over the face and neck, and every indication of an oppression of the brain, by this accumulation of blood. The most successful treatment is, to take off a quantity of blood immediately, and throw cold water on the head repeatedly. A strong stimulus, such as hartshorn, applied to the soles of the feet, has also a very good effect.

The fifth and last kind of fuel is wood, or fossil coals, in their crude state, which it is proper to distinguish from the charcoals of the same substances. The difference consists in their giving a copious and bright flame, when plenty of air is admitted to them, in consequence of which they must be considered as fuels very different from charcoal, and adapted to different purposes. Flaming fuel cannot be managed like the charcoals. If little air be admitted, it gives no flame, but sooty vapour, and a diminution of heat. And if much air be admitted, to make those vapours break out into flame, the heat is too violent. These flaming fuels, however, have their particular uses, for which the others are far less proper. For flame, when produced in great quantity, and made to burn violently, by mixing it with a proper quantity of fresh air, by driving it on the subject, and throwing it into whirls and eddies, which mix the air with every part of the hot vapour, gives a most intense heat. This proceeds from the vaporous nature of flame, and the perfect miscibility of it with the air.

As the immediate contact and action of the air are necessary to the burning of every combustible body, so the air, when properly applied, acts with far greater advantage on flame than on the solid and fixed inflammable bodies; for when air is applied to these last, it can only act on their surface, or the particles of them that are outermost; whereas, flame being a vapour or elastic fluid, the air, by proper contrivances, can be intimately mixed with it, and made to act on every part of it, external and internal, at the same time. The great power of flame, which is the consequence of this, does not appear when we try small quantities of it, and allow it to burn quietly, because the air is not intimately mixed with it, but acts only on the outside, and the quantity of burning matter in the surface of a small flame is too small to produce much effect. But when flame is produced in large quantity, and is properly mixed and agitated with air, its power to heat bodies is immensely increased. It is therefore peculiarly proper for heating large quantities of matter to a violent degree, especially if the contact of solid fuel with such matter is inconvenient. Flaming fuel is used, for this reason,

in many operations performed on large quantities of metal, or metallic minerals, in the making of glass, and in the baking or burning of all kinds of earthen ware. The potter's kiln is a cylindrical cavity, filled from the bottom to the top with columns of wares; the only interstices are those that are left between the columns; and the flame, when produced in sufficient quantity, is a torrent of liquid fire, constantly flowing up through the whole of the interstices, which heats the whole pile in an equal manner. Flaming fuel is also proper in many works or manufactories, in which much fuel is consumed, as in breweries, distilleries, and the like. In such works, it is evidently worth while to contrive the furnaces so, that heat may be obtained from the volatile parts of the fuel, as well as from the fixed; for when this is done, less fuel serves the purpose than would otherwise be necessary. But this is little attended to, or ill understood, in many of those manufactories. It is not uncommon to see vast clouds of black smoke and vapour coming out of their vents. This happens in consequence of their throwing too large a quantity of crude fuel into the furnace at once. The heat is not sufficient to inflame it quickly, and the consequence is a great loss of heat.

The quantity of watery fluid contained in fuel greatly affects the amount of heat it produces; much more, indeed, than is commonly admitted in practice. It is a well known law of chemistry, that the evaporation of liquids, or their conversion into steam, consumes, and renders latent, a great amount of caloric. When green wood, or wet coals, are added to the fire, they abstract from it, by degrees, a sufficient part of its heat, to convert their own sap or moisture into steam, before they are capable of being burnt. And as long as any considerable part of this fluid remains unevaporated, the combustion goes on slowly, the fire is dull, and the heat feeble. Green wood commonly contains a third, or more, of its weight of watery fluid, the quantity varying according to the greater or less porosity of different trees. Nothing is farther from true economy than to burn green wood, or wet coal, on the supposition that, because they are more durable, they will in the end prove more cheap. It is true, their consumption is less rapid; but to produce a given amount of heat, a far greater amount of fuel must be consumed. Wood that is dried under cover is better than wood dried in the open air, being more free from decomposition.

Fugue; a term derived from the Latin word *fuga* (a flight), and signifying a composition, either vocal or instrumental, or both, in which one part leads off some determined succession of notes called the *subject*, which, after being answered in the fifth and eighth by the other parts, is interspersed through the movement, and distributed amid all the parts in a desultory manner, at the pleasure of the composer; sometimes accompanied by other adventitious matter, and sometimes by itself. There are three distinct descriptions of fugues—the simple fugue, the double fugue, and the counter fugue.

The *simple fugue* contains but one subject, is the least elaborate in its construction, and the easiest in its composition.

The *double fugue* consists of two subjects, occasionally intermingled and moving together; and the *counter fugue* is that fugue in which the subjects move in a direction contrary to each other. In all the different species of fugues, the parts fly, or run after each other; and hence the derivation of the general name *fugue*.

Fuller; one employed in woollen manufactories to mill or scour cloths, serges, and other stuffs.

Fuller's Earth; a well-known mineral, generally of a greenish white colour, more or less mixed with brown, gray, or yellow; of a soft and friable texture, and somewhat unctuous to the touch. It consists chiefly of silex, alumine, and water. When thrown into water, it immediately absorbs it, and breaks down into a fine pulp. Its utility in removing grease from woollen cloths, and other fabrics, has given this earth a great value in commerce. There are very extensive beds of this earth in several counties in England, as Kent, Surrey, Sussex, and at Wavedon, near Woburn in Bedfordshire. We have noticed the valuable property of this earth of taking grease out of woollen and other cloths, which, on a large scale, is effected by the operation called *fulling*, whence its name has been derived. This, which is performed by a kind of water-mill, called a *fulling-mill*, is particularly necessary with respect to new cloths, for the purpose of depriving them of the grease and oil which have been used in their preparation, and thus enables their fibres to curl and intertwine during the fulling. The cleansing property of this earth depends entirely on its alumine, which readily absorbs the grease. The properties of good fuller's earth are a susceptibility of being diffused through water without forming a paste, and a great degree of fineness, as the particles of silex would otherwise injure the cloth. As an article of domestic utility, it might be more frequently used than it is for the cleaning and scouring of wooden floors and wainscots. In this respect, it might be rendered an excellent substitute for soap.

Fulling; the act of cleansing, scouring, and pressing stuffs, cloths, stockings, &c., to render them stronger, firmer, and closer; called also *milling*, because these cloths are in fact scoured by a *water-mill*. The principal parts of a fulling-mill are—the wheel, with its trundle, which gives motion to the tree or spindle, whose teeth communicate that motion to the pestles or stampers, which fall into troughs, wherein the cloth is put, with fuller's earth, to be scoured and thickened by this process of beating it.

Fulmination. In a variety of chemical combinations, it happens that certain of the principles assume the elastic state with such rapidity that the concussion of the air produced gives rise to a loud report. This is called *fulmination*, or, more frequently, *detonation*. Fulminating gold, fulminating silver, fulminating mercury, and gunpowder, are the most familiar substances of this kind. (For an account of them, see Gold, Silver, Mercury, and Gunpowder.)

Fulminic Acid; a peculiar acid, known in combination with certain metallic oxides, and first discovered with those of mercury and silver, with which it forms powerfully detonating compounds. The conditions necessary for forming these compounds are—that the silver or mercury be dissolved in a fluid which contains so much free nitric acid and alcohol, that, on the application of heat, nitric ether shall be freely disengaged. According to an analysis of fulminate of silver, made by MM. Gay-Lussac and Liebig, the acid of the salt is composed of 26 parts, or one atom, of cyanogen, and 8 parts, or one atom, of oxygen. It is therefore to be considered a true cyanic acid, and its salts may, with

propriety, be termed *cyanates*, and this notwithstanding it differs in so many respects from the cyanic acid of Wöhler (for an account of which, see PRUSSIC ACID).

FUMIGATION; means employed for the destruction of miasmata, or effluvia. The most efficacious substance for this purpose is chlorine; next to it the vapour of nitric acid; and, lastly, that of muriatic acid. The fumes of heated vinegar, burning sulphur, or the smoke of exploded gunpowder deserve but little attention as anti-contagionists.

FUNCTION, in *mathematics*. A quantity is said to be a function of another quantity when its value depends on that quantity and known quantities only; and it is said to be a function of several quantities when its value depends on those quantities and known quantities only.

FUNCTIONS, considered in regard to the actions of the body, are by physiologists divided into vital, animal, and natural. The vital functions are those necessary to life, and without which the individual cannot subsist; as the motion of the heart, lungs, &c. The natural functions are those which the body cannot subsist any considerable time without; as the digestion of the aliment and its conversion into blood. Animal functions include the senses of touching, tasting, seeing, &c., and the voluntary motions.

FUNDAMENTAL NOTE, in *music;* the principal note in a song, or composition, to which all the rest are adapted: it is called the *key* to the song.

FUNDS. See STOCKS and MONEY.

FURLONG, in *arithmetic;* a measure of length, consisting of forty poles, and equal to the eighth part of a mile.

FURLOUGH; leave granted to a soldier, or non-commissioned officer, to be absent for a given time from his regiment or company; in which case he is said to be on furlough.

FURNACE, in *manufactures;* a fire-place employed for melting, distilling, and other processes.

FUR TRADE. The fur trade with America commenced early in the seventeenth century, and was carried on by the early French emigrants. Quebec and Montreal were at first trading posts. The trade was then, as now, a barter of guns, cloth, ammunition, &c., for the beaver and other furs collected by the natives, and was effected by the intervention of the *voyageurs, engagés,* or *coureurs des bois*. These men carried burdens of merchandise on their backs to the Indian camps, and exchanged their wares for peltries, with which they returned in the same manner. Shortly after the discovery of the Mississippi, permanent houses, and in many places stockade forts, were built, and men of capital engaged in the trade. Detroit, Mackinac, and Green Bay, were settled in this manner. The manner of the fur trade has undergone no material alteration since. Traders now, at least with the more remote tribes, enter the Indian country with boats laden with goods, and manned with Canadian boatmen, who perform the same service above attributed to their ancestors. The *engagés* are a hardy, patient, and laborious race, habitually making exertions of which no other people are perhaps capable, and enduring all hardships and privations for small pay.

In 1670, shortly after the restoration of Charles II. that monarch granted to Prince Rupert and others, a charter, empowering them to trade, exclusively, with the aborigines in and about Hudson's Bay. A company, then and after called the *Hudson's Bay Company*, was formed in consequence. The trade was then more lucrative than at present. In the winter of 1783—4, another company was formed at Montreal, called the *North-west Fur Company*, which disputed the right of the Hudson's Bay, and actively opposed it. The Earl of Selkirk was at that time at the head of the Hudson's Bay, and conceived the plan of planting a colony on the Red River of Lake Winnepeg. Of this colony, the North-west Company was suspicious. In consequence of this, and the evil feelings naturally growing out of a contrariety of interest, a war ensued between the servants of the parties, and a loose was given to outrage and barbarity. Wearied, at last, the companies united, and are now known by the name of the *Hudson's Bay Fur Company*. The colony established by Lord Selkirk soon broke up, the settlers going to the United States.

Of all who have traded with the aborigines, the French were the most popular and successful. They did, and still do, conform to the manners and feelings of the Indians, better than the English and Americans ever could. Most of the persons now engaged in the fur trade, in the region north of the Missouri, are French; and they are much esteemed by the natives, with whom they frequently intermarry. The male offspring of these alliances are commonly employed as interpreters, *engagés*, &c. They are handsome, athletic men. Mixing the blood seems to improve the races. The Indian trade on the great lakes and the Upper Mississippi, with its branches, has long been in possession of the *North American Fur Company*, the principal directors of which are in the city of New York.

In the year 1822, a new company, entitled the *Columbian Fur Company*, was organized, to trade on the St. Peter's and Mississippi. It was projected by three individuals, who had been thrown out of employ by the union of the Hudson's Bay and North-west, as before mentioned. Its operations soon extended to the Missouri, whither its members went from the sources of the St. Peter's, with carts and waggons, drawn by dogs. When it had, after three years' opposition, obtained a secure footing in the country, it joined with the North American. There was another company on the Missouri at the same time.

Furs were also obtained from the Upper Missouri and the Rocky Mountains, as follows: Large bodies of men (under the pretence of trading with Indians, to avoid the provisions of the law) were sent from St. Louis, provided with traps, guns, and all things necessary to hunters and trappers. They travelled in bodies of from 50 to 200, by way of security against the attacks of the savages, till they arrived at the place of their destination, when they separated, and pursued the fur-clad animals singly, or in small parties. When their object was effected, they assembled with their peltry, and descended the Missouri. They did not always invade the privileges of the natives with impunity, but sometimes suffered severely in life and property. This system still continues, and its operatives form a distinct class in the state of Missouri. The articles used in the Indian trade are chiefly these: coarse blue and red cloth and fine scarlet, guns, knives, blankets, traps, coarse cottons, powder and ball, hoes, hatchets, beads, vermilion, ribbons, kettles, &c. The furs given in return are those of the beaver (but this is scarce on this side the Rocky Mountains), otter, musk-rat, marten, bear, deer, lynx,

and buffalo. Racoons are now of little value. The fur-clad animals, with the exception of the musk-rat, are now almost exterminated on the Mississippi and the great lakes, owing entirely to the fur trade. The skins of animals killed in summer are good for nothing; and the farther north the furs are taken, the better is their quality.

The course of a trader in the North-west is this: He starts from Michilimackinac, or St. Louis, late in the summer, with a Mackinac boat, laden with goods. He takes with him an interpreter, commonly a half breed, and four or five *engagés*. On his arrival at his wintering ground, his men build a store for the goods, an apartment for him, and another for themselves. These buildings are of rough logs, plastered with mud, and roofed with ash or linden slabs. The chimneys are of clay. Though rude in appearance, there is much comfort in them. This done, the trader gives a great portion of his merchandise to the Indians on credit. It is expected that the debtor will pay in the following spring, though, as many neglect this part of the business, the trader is compelled to rate his goods very high. Thus the honest pay for the dishonest. Ardent spirits were never much used among the remote tribes. It is only on the frontier, in the immediate vicinity of the white settlers, that the Indians get enough to do them physical injury, though, in the interior, the traders, in the heat of opposition, employ strong liquors to induce the savages to commit outrage, or to defraud their creditors. By this means, the moral principle of the aborigines is overcome, and often destroyed. Spirit is commonly introduced into their country in the form of high wines, they being less bulky, and easier of transportation, than liquors of lower proof. Indians, after having once tasted, become extravagantly fond of them, and will make any sacrifice, or commit any crime, to obtain them.

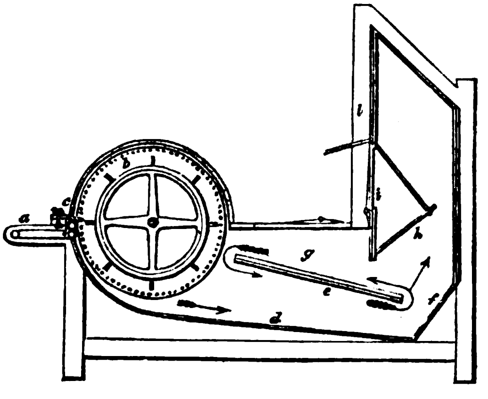
An interpreter is necessary to a fur trader, whether he speaks the language of the tribe with which he deals himself, or not. It is the duty of an interpreter to take charge of the house, and carry on the business in the absence of the principal. He also visits the camps, and watches the debtors. Those traders who are employed in the service of a company, as, for instance, the North American, are called *clerks*, though they seldom use a pen. Many of them cannot write or read. Some traders venture into the Indian country on their own account; but are usually overcome by the opposition of the established companies, whose servants employ every means to ruin them.

In the prairie region, dog-sledges are used for transportation in the winter. The sledge is merely a flat board turned up in front, like the runner of a sleigh. The dogs are harnessed and driven in line, and their strength and powers of endurance are very great. The laws regulating intercourse with the Indians require the traders to remain in their houses, and not to visit the Indians in their camps; but they are universally disregarded. It is better for the savage that they should be. Traders are always better clad and provided for travelling than Indians, and the latter are saved from the danger and hardship of exposure in the open prairie in winter. The competition that naturally results from the practice, is of advantage to them, as they get their wants supplied cheaper and more easily.

Those Indians who have substituted articles of European manufacture, for their primitive arms and vestments, are wholly dependent on the whites for the means of life, and an embargo on the trade is the greatest evil that can befal them. Did our limits permit, we could adduce instances. The fur trade demoralizes all engaged in it. The way in which it operates on the Indians has been already partially explained. As to the traders, they are, generally, ignorant men, in whose breasts interest overcomes religion and morals. As they are beyond the reach of the law (at least, in the remote regions), they disregard it, and often commit or instigate actions that they would blush to avow in civilized society. Most of them are connected with Indian women, after the custom of the country. In consequence of the fur trade, the buffalo has receded hundreds of miles beyond his former haunts. Fomerly, an Indian killed a buffalo, made garments of the skin, and fed on the flesh while it lasted. Now, he finds that a blanket is lighter and more convenient than the buffalo robe, and kills two or three animals, with whose skins he may purchase it. To procure a gun, he must kill ten. The same causes operate to destroy the other animals. Some few tribes, the Ottaways for example, hunt on the different parts of their domains alternately, and so preserve the game. But by far the greater part of the aborigines have no such regulation.

The fur-clad animals are now to be found in abundance only in the far north, where the rigour of the climate and the difficulty of transportation prevent the free access of the traders, and on the Upper Missouri, and towards the Rocky Mountains.

The preparation of hats is one of the principal uses to which fur is put in this country; we therefore select the present article for describing the mode of clearing the fur for that purpose. The process of felting has already been explained, and the complete formation of a hat will be given under HAT-MAKING. The patent improvements to which we are going to call the reader's attention, are exhibited in the diagram beneath, and are intended to separate the finer portions of the fur from those that are less costly.



An endless web, or feeding cloth, is shown at *a*. It is extended on two rollers, upon which web the materials to be cleared and separated are placed, and by which they are carried forward into the machine. *b*, is a hollow cylinder with a flanch at each extremity. From the rims of these flanches a number of cords of catgut are extended and made tight. A

peg or pin is so placed, the cords are put in vibration as they pass round, and thus take the material from the feeding cloth. To ensure a requisite current of air for carrying the fur onward, vanes are placed in the cylinder *b*. The precise amount of current is determined by the regulator, *e*, and the board *f*. The portions that are not sufficiently cleared are returned in the direction of the arrow towards *g*, while that which is completed goes out at *h*, and from thence into a larger upper chamber.

FUSTIC WOOD is of a yellow colour, and contains great quantities of colouring matter, forming the most durable of all the yellow dyes, which, however, is mostly used in compounding green and a variety of drab and olive colours, as, when employed alone, it is dull and deficient in clearness.

GADARA; a Turkish sabre with a large blade, somewhat curved.

GAILLIARDE; an ancient Italian dance, of a sportive character and lively movement, the air of which was in triple time. It was called, likewise, ***Romanesque***, because it was said to have come originally from Rome.

GALACTOMETER (*milk-measure*), invented by Cadet de Vaux. The first degree shows all pure milk; the second, milk with a fourth water; the third, milk with a third water; the fourth, milk with half water. Every one knows that the milk is richer towards the end than at the beginning of the milking. The milk of a pregnant cow, too, is richer than that of one which has just begun to be milked. Food, season, and rain, exercise a great influence on the quality of butter in the milk. The instrument seems, therefore, to be uncertain. (See LACTOMETER.)

GALAXY, in *astronomy*; that long, luminous track, or zone, which encompasses the heavens, forming nearly a great circle of the celestial sphere. It is inclined to the plane of the ecliptic at about an angle of 60°, and cuts it nearly at the two solstitial points. It traverses the constellations Cassiopeia, Perseus, Auriga, Orion, Gemini, Canis Major, and the Ship, where it appears most brilliant in southern latitudes; it then passes through the feet of the Centaur, the Cross, the southern Triangle, and returns towards the north by the Altar, the tail of the Scorpion, and the arc of Sagittarius, where it divides into two branches, passing through Aquila, Sagitta, the Swan, Serpentarius, the head of Cepheus, and returns into Cassiopeia. The ancients had many singular ideas as to the cause of this phenomenon; but modern astronomers have long attributed it to a great assemblage of stars, and Doctor Herschel has confirmed these conjectures, having discovered, in a space of about 15° long, by 2° broad, no fewer than 50,000 stars. This, however, instead of satisfying the curiosity of astronomers, only gave rise to farther inquiries and hypotheses; amongst others, that of Doctor Herschel, which is very interesting. He supposes the siderial universe to be distributed into nebulæ and clusters of stars, and the Milky Way to be that particular cluster in which our sun is placed.

In a paper on the construction of the heavens, Doctor Herschel says, It is very probable that the great stratum called the *Milky Way* is that in which the sun is placed, though perhaps not in the centre of its thickness, but not far from the place where some smaller stratum branches from it. Such a supposition wil l sati-factorily, and with great simplicity, account for all the phenomena of the Milky Way, which, according to this hypothesis, is no other than the appearance of the projection of the stars contained in this stratum and its secondary branch. Doctor Herschel then solves a general problem for computing the length of the visual ray. The telescope which he used will reach to stars 497 times the distance of Sirius. Now Sirius cannot be nearer than 100,000 × 190,000,000 miles; therefore Doctor Herschel's telescope will at least reach to 100,000 × 190,000,000 × 497 miles. And Doctor Herschel says that, in the most crowded part of the Milky Way, he has had fields of view that contained no fewer than 588 stars, and these were continued for many minutes; so that in a quarter of an hour he has seen 116,000 stars pass through the field of view of a telescope of only 15′ aperture; and, at another time, in 41 minutes, he saw 258,000 stars pass through the field of his telescope. Every improvement in his telescope discovered stars not seen before; so that there appears no bounds to their number, or to the extent of the universe.

GALBANUM is the concrete juice of the *bubon galbaniferum*, a shrubby plant, belonging to the natural order *umbelliferæ*, and is usually imported from Syria, Persia, and the East Indies. The galbanum of commerce, however, is perhaps obtained from several species of bubon. This gum-resin comes in large, soft, ductile masses, of a whitish colour, becoming yellowish with age, and possessing an acrid, bitter taste, with a strong disagreeable odour. In its medical properties, it is intermediate between ammoniac and assafœtida, which are likewise the products of plants of the same natural order. At present it is rarely used, but in combination with other articles it forms some officinal preparations.

GALEASSE; a low-built Venetian vessel with both sails and oars, which carries three masts, that cannot, however, be lowered as in a galley. It has thirty-two seats for rowers, and three tiers of guns at the head.

GALENA. See NATURAL HISTORY.

GALL, in the *animal economy*; the same with *bile*, which see.

GALL-BLADDER, called *vescicula* and *cystis fellia*, is usually of the shape of a pear, or the size of a small hen's egg. It is situated on the concave side of the liver, and lies upon the colon, part of which it tinges with its own colour. It is composed of four membranes, or coats—the common, the vesicular, the muscular, and the nervous one, which last is of a wrinkled or reticulated surface within, and furnished with an unctuous liquor. The use of the gall-bladder is to collect the bile secreted in the liver, and, mixing with its own peculiar produce, to perfect it farther, to retain it for a certain time, and then to expel it.

GALL-STONES; calculous concretions frequently formed in the gall-bladder, and sometimes occasioning great pain in their passage through the ducts into the *duodenum*, before they are evacuated. Gall-stones often occur in the inferior animals, particularly in cows and hogs; but the biliary concretions of these animals have not hitherto been examined with much attention. Soaps have been proposed as solvents for these *calculi*. The academy of Dijon has announced the success of a mixture of essence of turpentine and ether.

GALLATES; salts formed by the gallic acid with alkaline earths or metallic bases.

GALLEONS; formerly a kind of vessels of war, used by the Spaniards and Portuguese, with from three to four decks. They are no longer in use. In more recent times those vessels were called *galleons* in which the Spaniards transported treasure from their American colonies. The merchants engaged in this transportation were called *galleonists*.

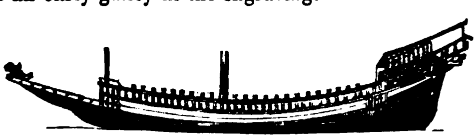
GALLERY, in *architecture;* a long, narrow room, the width of which is at least three times less than its length, by which proportion it is distinguished from a saloon. Corridors are sometimes also called *galleries*. Galleries are not destined to be occupied as sitting rooms, but for dancing, music, or dining on festival occasions; and are generally decorated with pictures in oil or fresco. Galleries have sometimes been built merely to receive collections of pictures, or to give a painter an opportunity for fresco paintings. Hence a large collection of pictures, even if contained in several adjoining rooms, is called *a gallery*.

The first gallery was established by Verres, the well-known spoiler of Sicily. Cicero describes it. It contained, among other beautiful works of art, a statue of Jupiter Οὔριος (the dispenser of favourable winds); the Diana Segestes, a grand and beautiful statue of bronze, veiled, bearing a quiver on her shoulder, holding a bow in her right hand, and a lighted torch in her left; Apollo and Hercules, the works of Myron; a Cupid by the hand of Praxiteles; a Sappho in bronze by Silanion; and the famous flute-player Aspendus. It also contained a splendid collection of vases, *pateræ*, &c., of gold and silver, decorated with costly gems and engraved stones. The pictures were of equal value and rarity, the tapestries embellished with rich borders of gold, and every part of the gallery enriched with all the splendour that art and wealth could bestow. In modern Europe, the gallery founded by Cosmo II., in Florence, was long considered as the most distinguished. At present, the *Galerie du Louvre*, at Paris, is the finest in the world, though, in 1815, it was stripped of many works of art, retaken by the different nations from whom they had been plundered.

Gallery; a balcony, projecting from the stern or quarter of a ship of war, or of a large merchantman.

Gallery, in *fortification;* a covered walk across the ditch of a town; and, as a *mine*, it is a narrow passage from one part of the mine to another.

GALLEY; a species of low, flat-built vessel, furnished with one deck, and navigated with sails and oars, particularly in the Mediterranean. The ancients employed galleys both in commerce and for military affairs. They thus sometimes formed large navies, manned almost entirely by soldiers; and, on account of the crowded state of the decks, seldom employed sails. The iron beak or prow was usually the most dangerous part of the galley, as it acted like a great battering-ram. We give a representation of an early galley in the engraving.



The largest sort of these vessels, called *galleasses*, were formerly employed by the Venetians. They were about 162 feet long above, and 133 feet by the keel, 32 feet wide, and 23 feet length of stern-post. They were furnished with three masts, and 32 banks of oars, each bank containing two oars, and every oar being managed by six or seven slaves, who were usually chained to it. In the fore-part, they had three small batteries of cannon, viz., two 36-pounders, two 24-pounders, and two 2-pounders. They had also three 18-pounders on each quarter, and carried from 1000 to 1200 men. The galleys next in size to these are called *half-galleys*, and are from 120 to 130 feet long, 18 feet broad, and 9 or 10 feet deep. They have two masts, which may be struck at pleasure, and are furnished with two large lateen sails, and five pieces of cannon. They have commonly 25 banks of oars, as described above. A size still less than these are called *quarter-galleys*, carrying from 12 to 16 banks of oars. They generally keep close under the shore, but sometimes venture out to sea to perform a summer cruise. France employs forty galleys for the use of the Mediterranean, the arsenal for which is at Marseilles. These galleys resemble the hulks in this country, in which the convicts labour and are confined.

Galley is also a name given to an open boat, rowing six or eight oars, and used on the river Thames by custom-house officers, press-gangs, and also for pleasure; hence the appellation of *custom-house galley, press-galley*, &c.

Galley, or *Gally*, is also the name of the kitchen of a ship of war, or the place where the grates are put up, fires lighted, and the victuals generally boiled or roasted. In East India ships, it is generally termed the *cook-room*, and on board of merchantmen, it is called the *caboose*.

GALLIC ACID has an intimate connection with tannin; they are generally associated in the vegetable astringents, and are similar in some of their most striking chemical relations. It derives its name from the gall-nut, in which it exists in large quantity, and from which it is usually obtained. Its presence is shown by the property which the infusion of galls has of reddening litmus; and it may be procured by a process given by Scheele,—merely allowing a strong infusion to remain in a vessel imperfectly closed for some months; a sediment is deposited; this being washed with cold water, and dissolved in boiling water, crystals of a grayish colour are procured, which are acid. Scheele observed, too, that by distillation, galls afford an acid liquor, and a portion of a concrete acid is condensed in a crystalline form. Other methods have been employed, such as dissolving the acid by highly concentrated alcohol, which leaves the tannin undissolved; abstracting the tannin and extract of the infusion of galls by the affinity of argil; or boiling in the infusion carbonate of barytes, and decomposing the gallate of barytes by sulphuric acid. But it is not certain if, by any of these processes, the acid is obtained in a state of purity, and in particular altogether free from tannin; this principle always adheres to the acid procured by the first process of Scheele, so as to render it capable of precipitating gelatin, and the other processes by chemical affinity succeed imperfectly. There remains, therefore, only the process of sublimation, and this probably gives the gallic acid in its purest state, a minute portion of oily matter only adhering to it, which gives it a slight aromatic odour; it gives no precipitate with gelatin, and therefore does not appear to have any intermixture of tannin. It is inferior, however, to the acid

procured by the spontaneous decomposition of the infusion of galls in acid powers, a difference which Lagrange considers as owing to the latter having combined with it a portion of acetic acid. With regard to the different states of this acid and its purity, there still remains, on the whole, considerable uncertainty.

The sublimed acid is procured in crystals of a white colour, if the heat has not been raised too high, so as to volatilize any vegetable matter, which gives it a brownish tinge. When purified by solution and crystallization, the acid is white; its crystals are slender prisms; its taste is sour; it reddens, though not very deeply, the vegetable colours, and excites effervescence in the alkaline carbonates; it requires 24 parts of cold water for its solution, but dissolves in less than 2 parts of boiling water, this solution crystallizing on cooling. It dissolves in 4 parts of alcohol, at a medium temperature.

Exposed to heat it fuses, exhaling an agreeable odour; a portion sublimes, and condenses in crystals, while a quantity of acid liquor is also produced, and a large quantity of charcoal remains in the retort. The concrete acid has nearly the same taste and odour as acid of benzoin. The products of its entire decomposition prove it to be a compound of carbon, hydrogen, and oxygen, containing a large proportion of carbon. By nitric acid it is converted into oxalic acid. According to Berzelius, it consists of 57 of carbon, 38 of oxygen, and 5 of hydrogen.

Gallic acid combines with the alkalies and earths. Its salts are named gallates; they have been little examined: those, with the alkalies, are soluble; they throw down dark-coloured precipitates from metallic solutions similar to those produced by the acid itself.

This property of forming dark-coloured precipitates with the solutions of metals, is the most important one belonging to the gallic acid, as rendering it a re-agent of considerable delicacy. The observations with regard to these, however, are of less value, as the acid has been usually employed in that state in which it has an intermixture with tannin; and we have no accurate comparative experiments with regard to the effects from it in a purer form. Its action on the salts of iron has been principally examined, and this is similar to that exerted by tannin. It strikes a violet or purple colour, more or less deep; but for the production of the colour, the iron requires to be in a high state of oxidation. It can also be rendered apparent, however, even in solutions at a lower state of oxidation, by causes which cannot change the state of oxygenation, as by dilution with water, or the addition of a little alkali: and the reason, therefore, of its not appearing when the salt contains the iron imperfectly oxidated, is, that the oxide in that state is retained by a stronger attraction in combination with the acid, than when the oxidation is more perfect. The colour, from the action of gallic acid, is less deep than that from tannin; and the precipitate is much finer, and remains longer suspended. There is some reason to suspect that the colour is always produced by tannin adhering to the acid, and that the acid, only by its re-action on the precipitate, holds it dissolved.

From this relation between gallic acid and tannin, and oxide of iron, arises the advantage derived from their combination in the formation of writing-ink, or black dyes, or the superiority of the infusion of a vegetable astringent, in producing the colour, to either of them in its separate state.

Galliot; a Dutch vessel, carrying a main and a mizzen mast, and a large gaff-main-sail. A galliot is a sort of a brigantine, or small galley, built very slightly, and designed only for chase. She can both sail and row, and usually carries about two or three *pedreros*, and has 16 or 20 oars. All the seamen on board are soldiers, and each has a musket by him on quitting his oar. Some also call the bomb-ketches *galliots*.

Gallon; a measure of capacity, being equal to four quarts, or eight pints. The standard of this measure, or the imperial gallon, is equal to ten pounds avoirdupois, or 277.274 inches of distilled water. The proportion of the imperial gallon to the old wine gallon is as 6 to 5 nearly.

Galloon, in *commerce;* a narrow kind of lace, used to edge or border cloths.

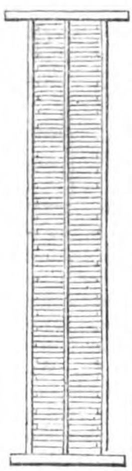
Gally, in *typography;* a frame into which the compositor empties the lines out of his composing-stick, and in which he ties up the page when it is completed. Some gallies are formed of an oblong square board, with a ledge on three sides, and a groove to admit a false bottom, called a *gally-slice.*

Galvanism. Although this agent is now generally admitted to be identical with electricity, yet its mode of production, and the laws which it observes when in action, are so far peculiar, that it is most advantageously treated of by itself.

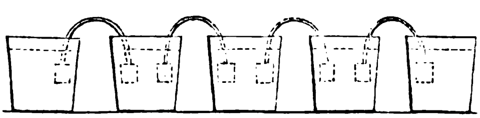
Its name is derived from *Galvani*, an Italian philosopher, who, in a course of experiments on animal irritability, observed the first striking phenomenon which led to its discovery. This observation related to the muscular contractions that take place in the leg of a frog recently killed, when two metals, such as zinc and silver, one of them touching the crural nerve, and the other the muscles to which it is distributed, are brought into contact with one another. The theory which he invented to account for this phenomenon was, that the different parts of an animal are in opposite states of electricity, and that the effect of the metal is merely to restore the equilibrium. The fallacy of this theory was fully shown, about ten years after, in the year 1800, by Volta, a celebrated professor of natural philosophy at Pavia, who excited similar contractions by making a connection between two parts of a nerve, between two muscles, or between two parts of the same muscle; but to produce the effect, two different metals were found to be requisite. He showed also, that in a similar way *sensations* can be excited; as, for example, a piece of silver being applied to one side of the tongue, and a piece of copper to the other, when their edges are brought into contact, or a connection is established between them by a conductor, a peculiar taste is felt, and often a flash of light appears to pass before the eyes. Hence he was led to infer, that the electricity is derived, not from the living system, but from the action excited between the metal and the humid animal fibre; that the animal matter acts merely as a medium conducting this electricity, and that the effects produced are to be ascribed to the stimulus of the electric fluid passing along the nerves and fibres, as in a shock from a Leyden jar.

In the farther demonstration of his views of the production of galvanism, Volta showed that plates of different metals, such as silver and zinc, in con-

tact with one another are excited, the silver negatively, and the zinc positively; and, by employing several pairs of these plates, connecting them in such a manner that the electricity excited by each pair should be diffused through the whole, he discovered a mode of greatly augmenting the galvanic energy, and presented to chemistry an unrivalled instrument of research. It consisted of any number of pairs of zinc and copper, or zinc and silver plates; each pair being separated from the adjoining ones by pieces of cloth, nearly of the same size as the plates, and moistened in a saturated solution of salt. The relative position of the metals in each pair was the same in the whole series; so that, if the copper was placed below the zinc in the first combination, the same order was preserved in all the others. The pile was contained in a frame, fixed into a piece of thick wood, which afforded the apparatus both support and insulation.



The pile is represented in the woodcut. The instrument thus arranged was found to be in the same state of excitement as the single pair of metallic plates, affecting the electrometer, and exciting muscular contractions, in a similar manner, but in a much greater degree. The opposite ends of the pile were also differently excited, the side which began with a zinc plate being positive, and the other negative; and hence, when they were made to communicate by means of a wire from each, electricity flowed from one to the other in a continued current. If the wires were applied to living matter, sensations and contractions were excited: they also gave the electric spark. This instrument, which is at present rarely used, in consequence of more convenient arrangements upon the same principle, has received the name of the *voltaic pile*. Another apparatus for the same purpose was invented by Volta, which he called the *couronne de tasses*. It consisted of a series of glass cups nearly filled with water or a saline solution. In each cup was placed a plate of zinc, and a plate of silver or copper; the plate of silver in the one cup being connected with that of zinc in the other, by a thin slip of metal bent into an arc, and the same order being preserved as in the construction of the pile. The best form of the *couronne de tasses* is given beneath.



Several improvements upon the voltaic pile were soon made by other philosophers; and the discoveries in galvanism multiplied with a rapidity, and to an extent, which surpass any thing before known in the history of science. In attempting to give an outline of these discoveries, we shall observe the following order:—1. *The construction of the galvanic apparatus, and the circumstances essential to the excitement of this modification of electricity; 2. its electrical effects; and 3. its chemical agency.*

1. The simple contact of *different conducting* bodies is all that is necessary for the excitement of galvanic electricity. Conductors of electricity have been divided into *perfect* and *imperfect;* the former comprehending the metals, plumbago and charcoal, the mineral acids, and saline solutions; the latter including water, alcohol and ether, sulphur, oils, resins, metallic oxides, and compounds of chlorine. The least complicated galvanic arrangement is termed *a simple galvanic circle.* It consists of three conductors; of which one, at least, must be solid, the second fluid; the third may be either solid or fluid. In the following tables, some different simple circles are arranged in the order of their powers; the most energetic occupying the highest place.

Table of electrical arrangements, which, by combination, form voltaic batteries, composed of two perfect conductors, and one imperfect conductor.

Zinc,	Each of these	Solution of nitric acid,
Iron,	is the positive	——— muriatic acid,
Tin,	pole to all the	——— sulphuric acid,
Lead,	substances be-	——— sal ammoniac,
Copper,	low it, and ne-	——— nitre,
Silver,	gative with re-	——— other neutral
Gold,	spect to those	salts.
Platina,	above it in the	
Charcoal.	column.	

Table of electrical arrangements, consisting of one perfect conductor and two imperfect conductors.

Solution of sulphu-	Copper,	Nitric acid,
ret of potash,	Silver,	Sulphuric acid,
——— potash,	Lead,	Muriatic acid,
——— soda.	Tin,	Any solutions
	Zinc,	containing
	Other metals,	acids.
	Charcoal.	

In explanation of these tables, it may be observed, that in all those cases where the fluid menstrua afford oxygen, those metals which have the strongest attraction for oxygen are those which form the positive pole. But when the fluid menstrua afford sulphur to the metals, the metal, which, under the existing circumstances, has the strongest attraction for sulphur, determines the positive pole. Thus, in a series of copper and iron plates, introduced into a porcelain trough, the cells of which are filled with water or with acid solutions, the iron is positive, and the copper negative; but when the cells are filled with a solution of sulphuret of potash, the copper is positive, and the iron negative. When one metal only is concerned, the surface opposite the acid is negative, and that in contact with the solution of the alkali and sulphur, or of its alkali, is positive.

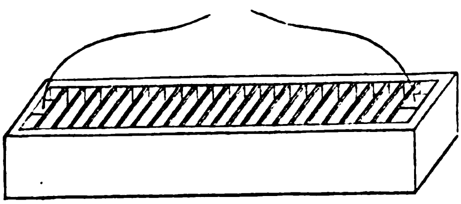
Simple galvanic circles are possessed of but feeble powers; yet these are often sufficiently obvious, as in the instance above alluded to, of a slip of zinc laid upon the tongue, and a piece of silver under it. In this case, we have an example of the arrangement of two perfect conductors (the metals) with one imperfect one (the tongue, or rather the fluids which it contains). A piece of zinc immersed in water which is freely exposed to the atmosphere, oxidises very slowly; but when placed in the same situation, in contact with a piece of silver, its oxidation is much more rapid. By immersing iron and silver (also in contact with each other) in dilute muriatic acid, the

action of the acid upon the iron is considerably increased; and hydrogen gas is evolved from the water, not only where it is in contact with the iron, but where it touches the silver. These facts explain why, in the sheathing of ships, it is necessary to use bolts of the same metal which forms the plates; for if two different metals be employed, they both oxidate very speedily, in consequence of their forming, with the water of the ocean, a simple galvanic circle.

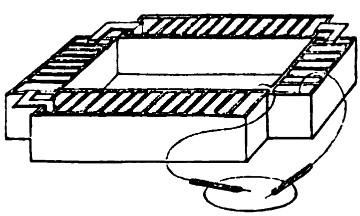
Compound galvanic circles, or galvanic batteries, are formed by multiplying those arrangements which compose simple circles. Thus, if plates of zinc and of silver, and pieces of woollen cloth of the same size as the plates, and moistened with water, be piled upon each other in the order of zinc, silver, cloth; zinc, silver, cloth; and so on, for twenty or more repetitions, we have the voltaic pile, the description of which was given in the previous page. The power of such a combination is sufficient to give a smart shock, as may be felt by grasping in the hands, previously moistened, the wires connecting the upper and lower extremities of the pile. The shock may be renewed at pleasure, until, after a few hours, the activity of the pile begins to abate, and finally ceases altogether.

But the galvanic apparatus by far the most convenient and generally used was invented by Mr. Cruickshank.

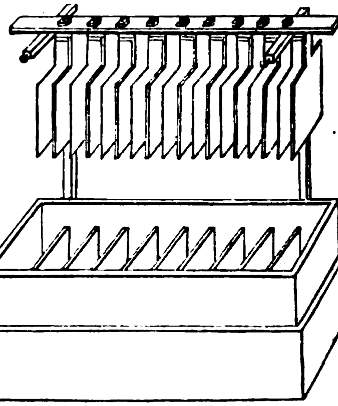
The *galvanic trough*, as it is named, and which consists of a long and narrow trough, made of baked wood, is shown beneath.



Grooves are cut in the trough, opposite to, and at the distance of ½ and ¾ of an inch from, each other; and into these are let down, and secured by a cement, square plates of zinc and copper, previously united together by soldering. The space, therefore, between each pair of plates forms a cell for the purpose of containing the liquid by which the combination is to be made active. The plates may be from 3 to 6 or 8 inches square; and care is to be taken, in their arrangement in the trough, that the order in which they are inserted be not in any instance reversed, but that the copper side of each double plate be always towards one hand, and the zinc side towards the other. The galvanic trough, thus constructed, is more easily put in action than the pile, and more easily kept clean; and, besides, it can be continued longer in action, as it contains more liquid.

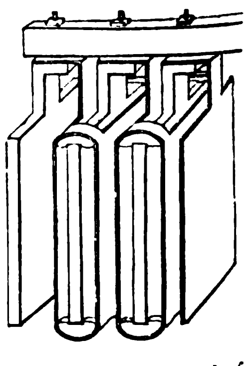


An improvement in the voltaic battery has been made, the hint for which was derived from the *couronne de tasses*: it consists in keeping the plates detached, instead of soldering them together. They are connected at the upper edge by a metallic arc, and are introduced into a trough divided into cells by partitions of glass (or sometimes into troughs wholly made of earthen ware), in such a manner that one plate is on one side of the partition, the other on the other. This arrangement has the advantage, that, both surfaces of each plate being acted on, a greater power is obtained.



In the above engraving the plates are shown suspended over a porcelain trough, which is the best form in which they can be constructed. The only practical objection to the arrangement is, that in some cases the acid acts on the glazed surface of the porcelain, and the troughs leak.

Dr. Wollaston has heightened the improvement, by placing in each cell one plate of the one metal, as the zinc, and two of the other, the copper, so that each surface of the zinc may be opposed to a surface of copper. The plates of copper are connected by metallic arcs, both at the top and bottom; and between them, supported by pieces of wood, is the plate of zinc, distant an eighth or a fourth of an inch from the copper on each side. The communication between these triple plates is established by arcs of lead or other metal, connecting each central zinc plate with the copper of the adjoining cell. This arrangement is very powerful in producing light and heat. A single series of this description is shown in the engraving.



An ingenious modification of this apparatus has been contrived by Dr. Hare, of Philadelphia. It consists of concentric coils of copper and zinc, so suspended by beams and levers as to be made to descend, at pleasure, instantaneously into the exciting fluid contained in glass jars or wooden troughs, without partitions. Each coil is formed from a zinc sheet of 9 inches by 6, and one of copper 14 by 6, more of the copper being required, as this metal is made to commence within the zinc, and completely

to surround it without. The sheets are so coiled as to leave between them interstices of a quarter of an inch. In the original apparatus, they were arranged in two rows, 40 coils in each: on their immersion in the appropriate fluid, the immediate evolution of heat and light was found to be most intense, far exceeding that of voltaic piles or troughs of an equal number of series and extent of surface; and on account of its superior power of causing the combustion of metallic wires and leaves, the instrument was named by its inventor the *galvanic deflagrator*.

The size of the plates composing the galvanic series has been varied from one or two inches square to that of a great number of feet. The battery of Mr. Children consisted of twenty pairs of copper and zinc plates, each plate being 6 feet long by 2 feet 8 inches broad. Each pair was connected by leaden straps at the top, and had a separate wooden cell. These cells were capable of containing 945 gallons of liquid. The plates were suspended from a wooden beam, by means of which they could at once be lowered into the cells, and again raised at pleasure.

Dr. Hare constructed an apparatus consisting of 20 sheets of copper and the same number of zinc, each 20 inches square, and so arranged as to be equivalent to a battery of two galvanic pairs, excepting that there is no insulation, all the plates being plunged into one vessel. This instrument, from its evolving caloric with scarcely any electricity, was called by Dr. Hare the *calorimotor*.

Different liquids are employed to fill the cavities of the trough; and it is essential to employ those which exert a chemical action upon one of the metals, the effect with pure water being very inconsiderable. In general, the galvanic effect is proportional to the rapidity with which the more oxidable metal is acted upon by the intervening fluid. Thus where the liquid employed is pure water, the electric excitement is very feeble, for the action on the metals is feeble; still the zinc is, even in this arrangement, observed to be oxidised more rapidly than it would be, were it not in contact with the copper. A saline solution, as of muriate of soda, or muriate of ammonia, is found to cause a more rapid oxidation of the zinc; and, accordingly, the electric power is greater; and, lastly, an acid fluid, which oxygenates and dissolves the metals much more rapidly, produces the highest activity of which the battery is capable. The fluid generally used is nitric acid, diluted with twenty or thirty times its weight of water.

The *electric column*, originally contrived by M. de Luc, is usually classed with galvanic arrangements. It is formed of discs of Dutch gilt paper, and similar discs of laminated zinc. These, in a perfectly dry state, are piled up into two columns, the different metals constantly alternating with each other in their position, until they attain the height of 18 inches, when they are coated over with a glass cylinder. They are then placed at the distance of 4 or 5 inches from each other, and between them is suspended, on a pivot, a light steel needle, which is attracted alternately to the one pile and the other, moving between them like a pendulum. This curious instrument, instead of being soon exhausted, like the pile, with humid substances, is found to continue active for several years, and has been applied to the measurement of time, by causing it to give motion to the pendulum of a clock.

2. *Electrical Effects of the Galvanic Battery*. Under this head are included all the effects which resemble the usual phenomena produced by the electrical machine. Galvanism, even when excited by a single galvanic circle, such as a piece of zinc, a similar one of copper, and a piece of cloth moistened with a solution of muriate of ammonia, distinctly affects the gold leaf of the condensing electrometer. If the zinc end be uppermost, and be connected directly with the instrument, the electricity indicated is positive. If the pin of the electrometer touch the copper, the electricity is negative. When wires connected with the opposite poles, or sides, of an active galvanic trough are brought near each other, a spark is seen to pass between them, accompanied with a slight snap or report; and on establishing a communication by means of the hands, previously moistened, a distinct shock is perceived, similar to that which is produced by the discharge of a Leyden jar. Both influences, also, are propagated through a number of persons without any perceptible interval of time.

On connecting the ends of a sufficiently powerful battery, by means of fine metallic wires, or slender pieces of freshly prepared charcoal, these conductors become intensely heated, and a vivid white light appears at the points of the charcoal; and as this phenomenon takes place equally in an atmosphere void of oxygen gas, or even under the surface of water, it manifestly cannot be ascribed to combustion. If the communication be established by metallic leaves, the metals burn with vivid scintillations: and if the galvanic fluid, in its circuit, be made to pass through gunpowder, phosphorus, and a mixture of hydrogen and oxygen gases, they are inflamed.

These observations induce the belief, that the agent or power excited by the voltaic apparatus is identical with that which is called into activity by the electrical machine: for not only may all the common electrical experiments be performed by means of galvanism, but it has been shown by Dr. Wollaston, that the chemical effects of the galvanic battery may be produced by electricity. The conditions required for producing the electrical effects of the voltaic battery are different. Electrical attractions and repulsions take place in the highest degree when a great number of small plates are employed, and the cells filled with water. For acting on the electrometer, therefore, a battery of numerous small plates is peculiarly suited, and common river water is the best material for its excitation.

For producing sparks, or giving shocks, a numerous series of plates, about four inches square, and excited with dilute acid, is required. For burning metallic leaves, fusing wire, and igniting charcoal, a small number of large plates answer better than a great number of small ones; a strong acid solution should also be employed.

3. *Chemical Effects of Galvanism*. The most simple chemical effect of the galvanic battery is the ignition and fusion of metals, which has already been alluded to above. The facility of being ignited, in the different metals, appears to be inversely proportional to their power of conducting heat. Hence platina, which has the lowest conducting power, is most easily ignited; and silver, which conducts heat with greater facility than any other metal, is ignited with more difficulty than any of the rest. The combustions produced by galvanic arrangements have also been spoken of above. The plates for this purpose should not be less than 4 inches square, and an aggregate of

not less than 150 pairs of plates employed. The metals are burnt, or rather deflagrated, in the form of very thin leaves. Gold emits a very vivid white light, inclining a little to blue; the flame of silver is a vivid green, somewhat like that of the emerald, and zinc a bluish white flame, fringed with red.

The most striking effect of the voltaic battery is the intense light which is produced by placing two pieces of charcoal, cut into the shape of pointed pencils, at the two ends of the wires of an interrupted circuit. When the battery is a very powerful one, and the charcoal points are brought within the 30th or 40th of an inch of each other, a bright spark is produced. By withdrawing the points from each other, a constant discharge takes place through the heated air, in a space of from one to four or more inches, according to the energy of the apparatus, producing a most brilliant arch of light, of considerable breadth, and in the form of a double cone. Platina, introduced into this arch, melts as wax does in the flame of a candle. This light equals the brilliancy of the sun, and cannot be borne by eyes of common strength, unless protected by glasses. That it does not arise from combustion, is proved by the fact, that very little of the charcoal is wasted by its continuance for some time.

In the use of the deflagrator, it was observed by Professor Silliman, that, during the discharge, the charcoal point of the positive pole shot out into a little stalactical knob, in the direction of the opposite point; while, in the charcoal of the negative pole, on the contrary, a crater-shaped cavity was formed at the same time, appearing as if matter was actually transferred from the negative to the positive side. The subsequent examination of the matter thus apparently transferred, as it had all the marks of having been fused, induced the belief that the charcoal passed, in the state of vapour, through the ignited arch of flame, and concreted again on arriving at the positive pole. The most important chemical effect of galvanism, however, is that of producing decomposition. The substance first decomposed by it was water. When two gold or platina wires are connected with the opposite poles of a battery, and their free extremities are plunged into the same cup of water, but without touching each other, hydrogen gas is disengaged at the negative wire, and oxygen at the positive side. By collecting the gases in separate tubes as they are formed, they are found to be quite pure, and in the exact proportion of two measures of hydrogen to one of oxygen.

If wires of a more oxidable metal are employed, the hydrogen gas will appear as usual, but the oxygen, instead of escaping, combines with the metal, converting it into an oxide. Numerous other compounds, such as acids and salts, are found to be decomposable in the same manner, one of these elements appearing at one side of the battery, and the other at the opposite extremity. A remarkable law in the circumstances attending the decomposition is also observed. Thus, in decomposing water, or any other compound, the same constituent principle is always disengaged at the same side of the battery; so that the principles which collect around each pole have a certain analogy; inflammable bodies and alkalies go to the negative side, while oxygen passes to the positive side.

It is also found, that not only are the elements of a compound fluid separated by galvanic energy to the opposite wires in distant parts of the containing vessel, without the movement of these elements being perceptible, but that the elements may even be evolved in separate portions of the fluid placed in distinct vessels, and connected only by some slight link, as a few fibres of moist cotton or amianthus. Thus two glasses may be filled with pure water and connected with moistened thread; the positive wire immersed in the water in one vessel, and the negative in that of the other; and immediately oxygen gas will be disengaged at the extremity of the former, and hydrogen gas at the extremity of the latter. Now, in this instance, it is obvious a difficulty immediately presents itself in attempting to account for the separate evolution of the elements. If they were both produced in one vessel, it might be conceived that they arose from the decomposition of one portion of water, and had been attracted to the opposite poles. But how can this happen in separate vessels? What becomes of the hydrogen in the vessel where the positive wire is placed, and why does oxygen not appear in the other vessel in which the negative wire is immersed? The only explanation that can be given, is to suppose that one or both of these ingredients must have passed from one vessel to the other, along the connecting fibres of thread, although we are unable to perceive such a transmission. Numerous other facts of a similar nature are also now known, particularly with respect to the decomposition of saline solutions. Thus, let two cups of agate or gold (as glass is liable to be acted upon) be connected by a few fibres of amianthus moistened by water, and a solution of sulphate of soda or potash, nitrate of potash, nitrate of silver, or any other compound salt, be placed in each of the cups. Now, if we introduce into one the positive wire, and into the other the negative wire of a galvanic battery in action, in a short time the principles of the salt will be separated, and all the acid will be collected in the vessel with which the positive pole communicates, and all the base in the other; each being conveyed by the medium of the moistened amianthus, and, as it would appear, in opposite currents, passing one another in so narrow a space, without combining or otherwise interfering with each other's movements. Again, if the saline solution be placed in one of the cups, and distilled water in the other, and the positive wire inserted in the latter, the acid will leave both the base with which it was united and the vessel in which it was, and pass by the amianthus wholly into the water, the base remaining in the first cup: and if, after this change be effected, the wires are reversed, the acid will immediately begin to quit the cup into which it had passed in the former experiment, and to return to the first cup, while the base will move in an opposite direction, till all of it is collected in the vessel in which the negative wire was placed.

Phenomena still more extraordinary present themselves in connection with these most interesting researches. The elements of compound bodies are actually conveyed by the influence of the electric current through solutions of substances, on which, under other circumstances, they would have exerted an immediate and powerful chemical action, without any such effect being produced. Acids, for example, may be transmitted from one cup, connected with the negative pole, to another cup on the opposite or positive side, through a portion of fluid in an intermediate cup tinged with any of the vegetable coloured

infusions, which are instantly reddened by the presence of an acid, without occasioning the slightest change of colour. The same happens also with alkalies. Sir H. Davy found that when three vessels were connected with each other by moistened amianthus, and there was placed in the first a solution of sulphate of potash, with a wire from the negative side, in the middle a vessel with a solution of ammonia (a substance having a strong attraction for sulphuric acid), and in the third water, with a wire from the positive side of the galvanic battery,—in five minutes (a battery of 150 pairs of plates being employed) acid was found collecting around the wire in the water. It had therefore passed through the ammonia without the affinity of this being sufficient to arrest it. When the disposition was reversed, and the saline solution connected with the positive side, the water with the negative, and an acid placed in the middle, the alkaline base was conveyed through the interposed acid, and collected in the pure water.

The same results were obtained in operating on a number of other salts, alkaline, earthy, and metallic. Where a strong force of cohesion, however, interfered, the substance was intercepted: thus sulphuric acid could not be transmitted through a solution of barytes or strontites; nor these earths through sulphuric acid: when it was attempted, these earths fell down in insoluble precipitates. Not only liquids, but solid substances, are decomposed by means of the galvanic energy, and their elements transferred to the opposite wires. And such is the force of this agent, that the most minute portion of a substance thus acted on by either of the wires is collected around it.

Portions of muriatic acid, of soda, and of other alkalies and acids, appear at the opposite poles, even when distilled water alone is employed; proving that these substances, in the condition of neutral salts, exist in all waters, however purified they may be by art. From these researches, the general law is established, that, when compounds are placed in the galvanic circuit, their elements are separated from the state of combination in which they exist, and, according to their peculiar nature, are collected, —some around the positive, others around the negative pole. How this is effected, whether by attractions alone exerted at each pole, or by repulsions, or by both, the element attracted to the one being repelled from the other, is not so apparent.

Grotthus, in explaining the galvanic decomposition of water, advanced the conjecture, that as, in the voltaic pile, each pair of plates has its negative and positive poles, it may establish a similar polarity among the elementary particles of the portion of water interposed between its principal poles. One element of the water may thus acquire the positive, the other the negative state; and, if this happens, then, according to the laws of electricity, that which has become negative (the oxygen in the case of water) will be repelled from the negative, and attracted to the positive pole; and that which has become positive (the hydrogen) will be repelled from the positive and attracted to the negative side. With regard to the mode of conveyance, it may be by successive decompositions and recompositions of the compound between the two poles; in water, for instance, the particle at each wire may be decomposed; the one element may be disengaged, and the residual element may attract a corresponding portion of the other from the next particle, and thus, by a series of successive decompositions and recompositions, each may be brought to the wire to which it is attracted and evolved; or, what is equally possible, the decomposition may be confined to the particles at each pole, and the element receiving the opposite electricity may be repelled from it, and, by this repulsion and the corresponding attraction at the opposite wire, be brought to that other pole; and analogy is in favour of this supposition. In atmospheric air, bodies rendered positively or negatively electrical are attracted and repelled at considerable distances. From the degree in which electricity exists in galvanic arrangements, water is a medium, with regard to it, nearly as atmospheric air is to electricity evolved in the common electrical machine; and it may therefore allow electric attractions and repulsions to operate in a similar manner.

A different theory has been proposed by Sir H. Davy, and which has received the appellation of the *electro-chemical theory*. It has been adopted by some eminent philosophers, and among others by Berzelius. He conceived that bodies possess natural electric energies, which are inherent in them, whether they are in a state of combination or not. Oxygen, chlorine, iodine, and acids, according to the theory, are naturally negative; while inflammables, as hydrogen, sulphur, &c., and metals, are naturally positive. Hence, when the combinations of these substances are subverted by the galvanic influence, the substances are evolved in the electric state natural to them; and, as it is a law of electricity that bodies in opposite states attract each other, the oxygen, being negative, is immediately attracted by the positive wire, while the inflammable or metallic base, being naturally positive, is attracted by the negative wire. In this way, the uniform appearances of these bodies at their particular poles is accounted for.

To explain how combination is subverted by the electric influence, a farther hypothesis was suggested by the author of this theory, viz. that chemical attraction may itself be a modification of electricity; that the same power which communicates attractive and repulsive properties to masses of matter may, when acting upon the ultimate particles of different bodies, induce them either to separate or unite, as their natural electrical states are the same or different. Thus, if hydrogen is naturally positive, and oxygen naturally negative, according to the laws of electricity, they must attract each other; and, if these opposite states are sufficiently elevated to give them an attractive force superior to the power of aggregation, they may be expected to combine; and, in like manner, other bodies, whose particles are in different states, may from this cause be united together. If a body also, whose electrical energy exceeds that of one of the substances combined, be brought to act upon these, it may expel that ingredient, and take its place; and this may be the cause of what is called decomposition from elective affinity.

The effect of heat, likewise, in promoting combination or decomposition, may often depend on its exciting electrical energy; and the elevation of temperature and production of light, so frequently attending chemical action, may depend on the changes attending the electrical states, since such changes are accompanied with the evolution of heat and light. The agency of the galvanic apparatus, then,

in producing decomposition, it is conceived on this hypothesis, is, that the two wires placed in contact with the compound are, in states of electricity, more intensely elevated than the natural states of the two ingredients; hence the attraction of these two highly electrified points overcomes that subsisting between these ingredients: they are separated, and immediately drawn to the respective poles,—the positive constituent to the negative wire, and the ingredient which is naturally negative to the positive wire. A number of facts are brought forward in support of these views. Thus, when dry acids, such as the oxalic and boracic, are touched with an insulated plate of copper, the electric equilibrium is immediately disturbed; the acids are found, after the contact, to be in the negative state of electricity, and the metal to be positive. Here then it was supposed, that their natural states are manifested, such as they are, inherently, at all times. Again, when the same plate is applied to earthy and alkaline substances, the opposite appearance is presented; the metal becomes negative, and the latter bodies positive. And, lastly, when acids are brought in contact directly with earthy and alkaline substances, the same relative states are exhibited—the former become negative, and the latter positive.

Regarding all compounds as constituted of oppositely electrical elements, Sir H. Davy conceived that none of them should resist decomposition, if exposed to a battery of sufficient intensity; and he accordingly subjected to galvanic action substances which till then had been regarded as simple, expecting that, if they were compound, they would be resolved into their elements. The alkalies and earths were in this manner successively decomposed; a substance, with the aspect and properties of a metal, appeared at the negative pole, while oxygen gas was disengaged at the positive surface.

Another instance of the successful application of these views is seen in the attempts of Sir H. Davy to protect the copper sheathings of ships from corrosion. It is well known that the copper sheathing of vessels oxidizes very rapidly in sea-water, and, consequently, wastes with such rapidity as to require frequent renewal. Sir H. Davy observed that the copper derived its oxygen from atmospheric air dissolved in the water, and that the oxide of copper then took muriatic acid from the soda and magnesia, forming with it a sub-muriate of the oxide of copper. Now, if the copper did not oxidize, it could not combine with muriatic acid; and, according to Sir H. Davy, it only combines with oxygen, because, by contact with that body, it is rendered positively electrical. If, therefore, the copper could by any means be made negative, then the copper and oxygen would have no tendency to unite.

The object was to render copper permanently negative. Now this is done by bringing copper in contact with zinc or iron; for the former then becomes negative, and the latter positive. Acting on this reasoning, it was found that the oxidation of the copper might be completely prevented. A piece of zinc as large as a pea, or the head of a small round nail, was found fully adequate to preserve 40 or 50 square inches of copper, and this wherever it was placed or under whatever form it was used. Every side and every surface of the copper remained bright, whilst the iron or the zinc was slowly corroded. Unhappily for the application of this principle in practice, it is found that unless a certain degree of corrosion takes place in the copper, its surface becomes foul, from the adhesion of sea-weeds and shell-fish. It is possible, however, that, by duly adjusting the proportion of iron and copper, a certain degree of corrosion may be allowed to occur, sufficient to prevent the adhesion of foreign bodies, and yet materially retarding the waste of the copper. A more successful application of these principles has been suggested by Mr. Pepys, of the Poultry, which is to preserve iron or steel instruments from rust by contact with a piece of zinc. The iron or steel is thereby rendered negative, while the zinc, being positive, oxidizes with increased rapidity. It is to the electro-chemical theory, also, that chemistry owes the most philosophical arrangement of which it appears capable. By it bodies are divided into groups, according as their natural electric energies are the same or different. The electric energies are ascertained by exposing compounds to the action of a galvanic battery, and observing the pole at which the elements appear. Those that collect around the positive pole are said to have a negative electric energy; and those are considered positive electrics which are attracted towards the negative pole.

The following list, showing the electric energy of the different elementary substances in relation to each other, is taken from Berzelius's *System of Chemistry*. They are given by their author as an approximation to their true order, rather than as rigidly exact. All bodies enumerated in the first row are negative to those of the second. In the first column, each substance is negative to those below it; and, in the second, each element is positive compared with the subsequent ones.

1.	2.
Negative Electrics.	*Positive Electrics.*
Oxygen.	Potassium.
Sulphur.	Sodium.
Nitrogen.	Lithium.
Chlorine.	Barium.
Iodine.	Strontium.
Fluorine.	Calcium.
Phosphorus.	Magnesium.
Selenium.	Beryllium.
Arsenic.	Yttrium.
Chromium.	Aluminium.
Molybdenum.	Zirconium.
Tungsten.	Manganese.
Boron.	Zinc.
Carbon.	Cadmium.
Antimony.	Iron.
Tellurium.	Nickel.
Columbium.	Cobalt.
Titanium.	Cerium.
Silicon.	Lead.
Osmium.	Tin.
	Bismuth.
	Uranium.
	Copper.
	Silver.
	Mercury.
	Palladium.
	Platina.
	Rhodium.
	Iridium.
	Gold.

Before concluding this part of the subject, it should be remarked, that, in the production of the different effects arising from the operation of galvanism, a dif-

ferent law is observed with regard to each of these effects, according as the structure of the galvanic arrangement varies. Thus, a few metallic plates, of a surface containing two or three square feet, will be powerful in producing heat and light, and will therefore deflagrate metallic leaves placed in the circuit, and illuminate charcoal points vividly; but the battery which they form will display little power of electrical attraction and repulsion, will have comparatively little effect on sentient organs, scarcely producing any shock, and will act feebly in producing chemical decomposition. Thus the great battery of Mr. Children and the deflagrator of Dr. Hare, which melted many feet of platina with ease, had no very remarkable power in effecting decomposition, or in giving shocks. If the same amount of surface, however, as existed in either of these arrangements, had been disposed in a battery, so as to have formed four times the number of plates, the result would have been that the burning effect would have been diminished, while it would have exhibited more evidently the different electrical states, and been more powerful in exciting sensations in animal organs, and in giving rise to chemical decompositions.

Gamboge is the inspissated juice of a foreign tree, and is obtained in commerce in masses of a dull orange colour, with a conchoidal fracture, possessing no smell, but an acrid taste, which is very slowly developed. When ignited, it melts, throwing out a dense smoke with sparks; it is soluble, or, more properly, diffusible in water, affording a beautiful colour, very much employed by painters; it is also used to stain wood in imitation of box; and the tincture enters into the composition of the gold-coloured varnish with which white wood manufactures are overlaid. It is said to give also a beautiful and durable yellow stain to marble. Its medical properties are violently purgative. When taken in large quantities it produces death. The best remedy for an over-dose is milk with a little opium.

Gaming, Laws of, mathematically considered, involve the doctrine of chance or hazard. It is, or is supposed to be, an equality of chance upon which the gamesters set out: this equality is to be broken in upon in the course of the game, by the greater good fortune or address of one of the parties, upon which his chance becomes better; so that his share in the deposit, or stakes, is now proportionably improved. This increase and decrease of favourable circumstances is continually varying, and runs through all the ratios between equality and infinite difference; or from an infinitely great one, upon which the game is ended. The whole game, therefore, with respect to the event or issue thereof, is only a change of the quantity of each person's share, or chance, or of the proportion their two shares bear to each other; which mathematics alone can measure. Hence several authors have computed the variety of chance, in several cases and circumstances, that occur in gaming, particularly M. de Moivre, in a treatise entitled *The Doctrine of Chances*, the best edition of which was published in 1756.

It is not our intention to enter into a full investigation of the nature and laws of chance, but merely to explain the essential principles of the doctrine. The *probability* of the happening of any event is to be understood as the ratio of the chances by which that event may happen, to all the chances by which it may either happen or fail; and it may be expressed by a fraction whose numerator is the number of chances whereby the event may happen, and whose denominator is the number of chances whereby it may either happen or fail. Thus, if there be a chances for the happening of any event, and b chances for its not happening, then will the probability of such an event taking place be truly represented by $\frac{a}{a+b}$.

In like manner, the probability of any event failing (or of its not happening) may be expressed by a fraction whose numerator is the number of chances whereby it may fail, and whose denominator is, as before, the whole number of chances whereby it may either happen or fail. Thus, the probability of the above event failing will be truly expressed by $\frac{b}{a+b}$. Since the sum of the two fractions representing the probabilities of the happening and of the failing of any event is equal to unity, it follows that, one of them being given, the other may be found by subtraction. Thus, the probability of an event happening being denoted by $\frac{a}{a+b}$, the probability of the same event failing will be truly represented by $1 - \frac{a}{a+b} = \frac{b}{a+b}$; and *vice versâ*.

If, upon the happening of an event, a person be entitled to a given sum of money, his *expectation* of receiving that sum has a determinate value before the happening of the event; and such value is ascertained by multiplying the sum expected by the fraction which represents the probability of obtaining it. Thus, if a person has a chances of obtaining, and b chances of losing a certain sum of money, s, then will $s \times \frac{a}{a+b}$ denote his expectation of receiving such sum, and will be the true value of his interest therein.

These principles may be more familiarly explained by the following example:—Suppose that a person has three chances in five to obtain 100*l.*; the value of his *expectation* is the product of 100*l.* by the fraction $\frac{3}{5}$, and consequently it is worth 60*l.* For, supposing that an event may equally happen to any one of five different persons, and that the person to whom it does happen should, in consequence of it, obtain the sum of 100*l.*, it is plain that the right which each of them in particular has upon the sum is $\frac{1}{5}$ of 100*l.*; which right is founded upon this principle, that if the five persons concerned in the happening of the event should agree not to stand the chance of it, but to divide the sum expected among themselves, then each of them must have $\frac{1}{5}$ of 100*l.* for his pretension. Now, whether they agree to divide that sum equally among themselves, or rather choose to stand the chance of the event, no one has thereby any advantage or disadvantage, since they are all upon an equal footing, and consequently each person's *expectation* is worth $\frac{1}{5}$ of 100*l.* Let us farther suppose that two of the five persons concerned in the happening of the event should be willing to resign their chance to one of the other three; then the person to whom these two chances are thus resigned has three chances that favour him, and consequently he has now a right to triple of what he had before, and therefore his expectation will be worth $\frac{3}{5}$ of 100*l.* Now, if we consider that the fraction $\frac{3}{5}$ expresses the probability of obtaining

the sum of 100*l*., and that $\frac{3}{5}$ of 100 is the same as $\frac{3}{5} \times 100$, we must naturally fall into the conclusion laid down, that the expectation of receiving any sum is determined by multiplying such sum by the probability of obtaining it; and, though this method of reasoning is deduced from a particular case, it will easily be perceived that it is general, and applicable to any other case.

The probability of the happening of *several events* that are independent of each other is equal to the product of the probabilities of the happening of each event considered separately. Thus, if the probability of the happening of the first of any number of independent events be denoted by $\frac{a}{a+b}$, that of the second by $\frac{c}{c+d}$, that of the third by $\frac{e}{e+f}$, &c. &c.; then will $\frac{a}{a+b} \times \frac{c}{c+d} \times \frac{e}{e+f} \times$, &c., denote the probability of the happening of all these events. And this expression, multiplied by the given sum, will denote the value of the *expectation* of receiving such sum on the happening of those events.

For example: suppose that, in order to obtain 100*l*., two events must happen, the first of which has three chances to happen and two to fail, and the second of which has four chances to happen and six to fail; the value of the expectation will in such case be $\frac{3}{5} \times \frac{4}{10} \times 100 = 24l.$, the demonstration of which will be very easy, if it be considered that, supposing the first event had happened, the expectation (then depending entirely upon the second) would, before the determination of the second, be worth $\frac{4}{10} \times 100 = 40l.$ We may therefore look upon the happening of the first as a condition of obtaining an expectation worth 40*l*.; but the probability of the first event happening has been supposed $\frac{3}{5}$, wherefore the expectation sought for is to be estimated by $\frac{3}{5} \times \frac{4}{10} \times 100 = 40$; that is, by the product of the two probabilities of happening multiplied by the sum expected. The same method of reasoning may be applied to the happening of three, or any other number of events, as may be seen more at large in the various authors who have treated on this subject.

By a similar method of reasoning, it will be evident that the probability of the failing of any number of independent events is equal to the product of the probability of the failing of each event considered separately; and the probability of the happening of any one of a number of independent events is denoted by the difference between unity and the expression mentioned in the last article.

In like manner, if the expectation of receiving any sum depends upon the happening of any number of independent events, and upon the failing of any number of other independent events, its value will be equal to such sum multiplied by the probability of all the latter failing. And from these principles we may determine the value of an expectation depending on the happening or failing of as many independent events as may be assigned.

Gammut; the name given to the table or scale laid down by Guido, to the notes of which he applied the monosyllables *ut, re, mi, fa, sol, la*. Having added a note below the lowest tone of the ancients, he adopted for its sign the *gamma* of the Greek alphabet; and hence his scale was afterwards called *gammut*. This gammut consisted of 20 notes, viz. two octaves and a major-sixth. The first octave was distinguished by capital letters, as G, A, B, &c.; the second by small letters, as g, a, b, &c., and the supernumerary sixth by double letters, as gg, aa, bb, &c. By the word *gammut*, we now generally understand the whole present existing scale; and to learn the names and situations of its different notes is to learn the gammut. It, however, sometimes simply signifies the lowest note of the Guidonian or common compass.

Gangrene is a great and dangerous degree of inflammation, wherein the parts begin to be in a state of mortification.

Gangway; a narrow platform, or range of planks, laid horizontally along the upper part of a ship's side, from the quarter-deck to the forecastle, peculiar to ships that are deep waisted, for the convenience of walking more expeditiously fore and aft, than by descending into the waist. It is fenced on the outside by iron stanchions, and ropes or rails, and, in vessels of war, with a netting, in which part the hammocks are stowed. In merchant ships, it is frequently called the *gangboard*.

Gangway is also that part of a ship's side, both within and without, by which persons enter and depart. It is provided with a sufficient number of steps, or cleats, nailed upon the ship's side, nearly as low as the surface of the water, and sometimes furnished with a railed accommodation ladder, resembling a flight of stairs, projecting from the ship's side, and secured by iron braces.

Gangway is also used to signify a narrow passage left in the hold, when a ship is laden, in order to enter any particular place as occasion may require, whether to examine the situation of the provisions or cargo, to discover and stop a leak, or to bring out any article that is wanted.

Gardant, in *heraldry*; an epithet for a beast of prey that is borne full-faced guarding, as a *lion-gardant*. The leopard is not so termed, because it is always borne so.

Gardening. Herder, in his *Kalligone*, calls gardening the second liberal art, architecture the first. "A district," says he, "of which every part bears what is best for it, in which no waste spot accuses the indolence of the inhabitants, and which is adorned by beautiful gardens, needs no statues on the road; Pomona, Ceres, Pallas, Vertumnus, Sylvan, and Flora meet us with all their gifts. Art and nature are there harmoniously mingled. To distinguish, in nature, harmony from discord,—to discern the character of every region with a taste which developes and disposes to the best advantage the beauties of nature,—if this is not a fine art, then none exists." However true it may be that gardening deserves to be called a fine art, we can hardly agree with Herder, that it is the second in the order of time; for, though gardens must have originated soon after man had advanced beyond the mere nomadic life, yet the practice of gardening as a fine art, that is not merely as a useful occupation, must necessarily have been of a much later date.

The hanging gardens of Semiramis are reckoned among the wonders of the world; but that which astonishes is not therefore beautiful. Scaffoldings, supported by pillars, covered with earth, bearing trees, and artificially watered, are, no doubt, wonderful; but we have no reason to suppose them beautiful. The gardens of the Persians are called by

Xenophon delightful places, fertile and beautiful; but they seem rather to have been places naturally agreeable, with fruit-trees, flowers, &c., growing spontaneously, than gardens artificially laid out and cultivated. Whether the Greeks, so distinguished in the fine arts, neglected the art of gardening, is a question not yet decided.

The gardens of Alcinoüs were nothing but well laid out fruit orchards and vineyards, with some flowers. The grotto of Calypso is more romantic, but probably is not intended to be described as a work of art. The common gardens which the Greeks had near their farms were more or less like the gardens of Alcinoüs. Attention was paid to the useful and the agreeable, to culinary plants, fruits, flowers, shadowing trees and irrigation. Shady groves, cool fountains, with some statues, were the only ornaments of the gardens of the philosophers at Athens. The descriptions of gardens in the later Greek novelists do not show any great progress in the art of gardening in their time; and it would be worth while to inquire, whether the same cause, which prevented the cultivation of landscape-painting with the ancients, did not also prevent the progress of the art of gardening. The ancients stood in a different relation to nature from the moderns.

The true art of gardening is probably connected with that element of the romantic which has exercised so great an influence on all arts ever since the revival of arts and letters, and, in some degree, ever since the Christain era. Even the grottoes of the ancients owed their origin merely to the desire for the coolness they afforded. Natural grottoes led to artificial ones, which were constructed in the palaces in Rome, and in which, as Pliny says, nature was counterfeited. But a grotto does not constitute a garden; and that the Romans had no fine gardens, in our sense of the word, is proved by several passages of their authors, and by the accounts we have of their gardens. In Pliny's description of his Tuscan villa, we find, indeed, all conveniences—protection against the weather, an agreeable mixture of coolness and warmth; but every thing beautiful relates merely to buildings, not to the garden, which, with its innumerable figures of box, and in its whole disposition, was as tasteless as possible. Of the gardens of Lucullus, Varro says, that they were not remarkable for flowers and fruits, but for the paintings of the villa. A fertile soil, and a fine prospect from the villas, which were generally beautifully situated, seem to have satisfied the Romans.

Whatever the art of gardening had produced among them, was, with every other trace of refinement, swept away by the barbarians who devastated Italy. Charlemagne directed his attention to this art, but his views did not extend beyond mere utility. The Troubadours of the middle ages speak of symmetrical gardens. In Italy, at the time of the revival of learning, attention was again turned towards pleasure gardens, some of which were so famous, that drawings were made of them. They may have been very agreeable places, but we have no reason to suppose them to have exhibited much of the skill of the scientific gardener. At a later period, a new taste in gardening prevailed in France. Regularity was carried to excess; clipped hedges, alleys laid out in straight lines, flower-beds tortured into fantastic shapes, trees cut into the form of pyramids, haystacks, animals, &c., were now the order of the day. The gardens corresponded with the taste of the time, which displayed itself with the same artificial stiffness in dress, architecture, and poetry. Lenotre was the inventor of this style of French gardening, which, however, his successors carried to greater excess. Nothing natural was left, and yet nature was often imitated in artificial rocks, fountains, &c. Only one thing strikes us as truly grand in gardens of this sort—the fountains, which were constructed at great expense. The Dutch imitated the French. Our own countrymen were the first that felt the absurdity of this style. Addison attacked it in his Essays on Gardening, in the *Spectator;* and Pope, in his fourth *Moral Epistle*, lashed its petty, cramped, and unnatural character, and displayed a better taste in the garden of his little villa, at Twickenham; crowds followed him, and practice went before theory. (See Horace Walpole's ***History of Modern Taste in Gardening.***) This style, however, was also carried to excess. All appearance of regularity was rejected as hurtful to the beauty of nature, and it was forgotten, that if in a garden we want nothing but nature, we had better leave gardening altogether. This extreme prevailed, particularly after the Oriental and Chinese style had become known. What in nature is dispersed over thousands of miles, was huddled together on a small spot of a few acres square—urns, tombs; Chinese, Turkish, and New Zealand temples; bridges, which could not be passed without risk; damp grottoes; moist walks; noisome pools, which were meant to represent lakes; houses, huts, castles, convents, hermitages, ruins, decaying trees, heaps of stones;—a pattern-card of every thing strange, from all nations under heaven, was exhibited in such a garden. Stables took the shape of palaces, kennels of Gothic temples, &c.; and this was called nature! The folly of this was soon felt, and a chaster style took its place. At this point we have now arrived.

The art of gardening, like every other art, is manifold; and one of its first principles, as in architecture, is to calculate well the means and the objects. Immense cathedrals and small apartments, long epics and little songs, all may be equally beautiful and perfect, but can only be made so by a proper regard to the character of each. Thus the climate, the extent of the grounds, the soil, &c., must determine the character of a garden. Aikin justly observes, that nothing deviates more from nature than the imitation of her grand works in miniature. All deception ceases at the first view, and the would-be magnificent garden appears like a mere baby-house. Let the character of the agreeable, the sublime, the awful, the sportive, the rural, the neat, the romantic, the fantastic, predominate in a garden, according to the means which can be commanded. This is not so easy as might appear at first, and it requires as much skill to discover the disposition which should be made of certain grounds, as to carry it into effect; but, if such skill were not required, gardening would not be an art. Another principle, which gardening has in common with all the fine arts, is, that it is by no means its highest aim to imitate reality, because reality will always be better than imitation. A gardener ought to study nature, to learn from her the principles and elements of beauty, as the painter is obliged to do; but he must not stop there. As another general remark, we would observe, that the true style of gardening lies between the two extremes. It is by no

means a reproach to a garden, that it shows the traces of art, any more than it is to a drama. Both, indeed, should follow nature; but, in respect to the fine arts, there is a great difference between a free following of nature and a servile copy of particular realities.

Gari, in *commerce;* an imaginary specie, or nominal coin, used in many parts of the East Indies, equal to about 4000 rupees.

Garlic. This vegetable has a strong, penetrating odour, and pungent, acrid taste. It differs from the onion only by being more powerful in its effects.—In warm climates, where garlic is produced with considerably less acrimony than in cold ones, it is much used, both as a seasoning and as a food. When bruised and applied to the skin, it causes inflammation, and raises blisters. In the south of Europe, particularly in Spain, it is very much used, entering into the composition of almost every dish, not only among the common people, but among the higher classes of society; and it is every where prized by epicures. At all times, however, there has been much contrariety of opinion as to its value; for we find it admired by some nations, and detested by others, as by the ancient Greeks. Its cultivation is easy, being a hardy plant, growing in almost every kind of soil; and it is reproduced by planting the radical or floral bulbs.—Its medicinal virtues have also been much celebrated. It not only forms an excellent expectorant, but has been administered in a great variety of diseases, as hysteria, dropsy, cutaneous eruptions, obstructions, &c. The juice of garlic is a strong cement for broken glass. Snails, worms, and the larvæ of insects, as well as moles, and other vermin, may all be driven away by placing preparations of garlic in or near their haunts. The virtues of garlic are most perfectly and readily extracted by spirit of wine.

Garnet. See Natural History.

Garrison; a body of men stationed in a fortress, city, village, intrenchment, &c., for the sake of defending it. The rules, by which the proper force of a garrison is determined, differ. Some reckon, for every five feet in circumference, one man; others, for every bastion, 200 soldiers. Vauban assigns, if the fortress is provided with ravelins, and a covered-way, for every bastion, 500 or 600 men; for every hornwork, or other large outwork, 600 more; for every detached redoubt, 150 men; for every detached fort, 600 to 800, according to its extent. The cavalry is fixed by him in the proportion of one-tenth of the infantry

Garter, Order of the, in *heraldry;* a military order of knighthood, instituted by King Edward III. It consisted originally of 26 knights companions, generally princes and peers, whereof the king is the sovereign or chief. The number was increased to 32 in 1786. The college of the order is in the royal castle of Windsor, with the chapel of St. George, and the chapter house, erected by the founder. The habit and ensign of the order are a garter, mantle, cap, George, and collar. The garter, mantle, and cap were assigned to the knights companions by the founder, and the George and collar by Henry VIII. The garter is worn on the left leg, between the knee and the calf, and is enamelled with this motto: *Honi soit qui mal y pense* (literally, Evil to him that evil thinks).—The origin of the order is variously related. "A vulgar story," says Hume, "prevails, but is not supported by any ancient authority, that, at a court ball, Edward's (III.) mistress, commonly supposed to be the Countess of Salisbury, dropped her garter; and the king, taking it up, observed some of the courtiers to smile, as if they thought that he had not obtained this favour by accident; upon which he called out, *Honi soit qui mal y pense.*" Other accounts, equally uncertain, are given.

Gas is the name of every permanently elastic aëriform substance. Gas is distinguished from steam, or vapour, by this circumstance—that vapours are raised from fluids by heat, and are again condensable by cold into the same fluid form; but gases are obtained from the substances containing them only by chemical decomposition, whether this be spontaneous or artificial.

All air was considered as a uniform, homogeneous substance, till about the middle of the last century, when it was discovered that there existed at least as great differences among aëriform as among fluid substances. Accustomed, however, to regard the atmosphere as the only air, philosophers called these new forms of air *gases*, to distinguish them from it. This name had been already introduced to the sciences by Van Helmont, and was derived from the old German word *giesch*. Every gas consists of some ponderable base, or substance, which is maintained in its aëriform state by means of heat or caloric; thus all gases possess common properties of elasticity, &c., which they derive from the last substance; and also each one its distinguishing or peculiar characters, derived from the substance constituting its base. Each kind of gas has also its own peculiar and uniform specific gravity, or weight, although they are all several hundred times lighter than water. The density of all gases is, like that of air, proportioned to the pressure to which they are subjected; and, like air, they expand with the application of heat, and are rendered more dense by its abstraction. (For a description of the various gases, see the articles in their alphabetical order.)

Gas-lighting. The producing from coal an aëriform fluid capable of furnishing a pure and brilliant light, and conveying it to a distance of many miles from the reservoir where it is generated, may justly be considered as one of the proudest triumphs of practical chemistry. Not that the illumination with carburetted hydrogen gas is the exclusive property of the present age; for we find the Guebre at Baku falling down to worship the element of fire in the form of this gas many centuries back. Strictly speaking, we believe that Mr. Winsor was the first who practically applied gas to the illumination of streets and houses; and it is painful to find that neither he nor his family, after having expended a large fortune in bringing it into public use, met with any proper national requital. That coal evolves a permanently elastic and inflammable aëriform fluid, seems first to have been experimentally ascertained by the Rev. Dr. Clayton; and a brief account of his discovery is published in the *Philosophical Transactions* for the year 1739.

The following is an extract from his paper:—"I got some coal, and distilled it in a retort in an open fire. At first there came over only phlegm, afterwards a black oil, and then likewise a spirit arose, which I could no ways condense; but it forced my lute or broke my glasses. Once, when it had forced my lute, coming close thereto, in order to try to repair it, I observed that the spirit which issued from it caught fire at the flame of the candle, and continued burning with violence, as it issued out in

a stream, which I blew out and lighted again alternately for several times. I then had a mind to try if I could save any of this spirit, in order to which, I took a turbinated receiver, and putting a candle to the pipe of the receiver, whilst the spirit arose, I observed that it catched flame, and continued burning at the end of the pipe, though you could not discern what fed the flame. I then blew it out and lighted it again several times; after which I fixed a bladder, squeezed and void of air, to the pipe of the receiver. The oil and phlegm descended into the receiver; but the spirit, still ascending, blew up the bladder. I then filled a good many bladders therewith, and might have filled an inconceivable number more, for the spirit continued to rise for several hours, and filled the bladders almost as fast as a man could have blown them with his mouth; and yet the quantity of coals distilled was inconsiderable. I kept this spirit in the bladders a considerable time, and endeavoured several ways to condense it, but in vain. And when I had a mind to divert strangers or friends, I have frequently taken one of these bladders, and pricking a hole therein with a pin, and compressing gently the bladder near the flame of a candle till it once took fire, it would then continue flaming till all the spirit was compressed out of the bladder; which was the more surprising, because no one could discern any difference in the appearance between these bladders and those which are filled with common air. But then I found that this spirit must be kept in good thick bladders, as in those of an ox, or the like; for, if I filled calves' bladders therewith, it would lose its inflammability in twenty-four hours, though the bladders became not relaxed at all."

The mode of manufacturing gas is simple, and may easily be understood. The coal to be subjected to destructive distillation is placed in an iron retort or oven, and, a fire being applied beneath, gas is speedily driven off. The gas thus obtained is very impure, so that it becomes necessary to pass it through lime-water, and also to condense the tar, both of which processes are performed before it reaches the gasometer or reservoir.

Mr. Peckston, in his work on coal gas, states, that a chaldron of Newcastle Wall's End coal will yield 10,000 feet, supposing it decomposed under the most advantageous circumstances; 2 cwt. will therefore yield about 750 feet. At Edinburgh, 2 cwt. of Parrot coal yield, on an average, 860 feet of gas. According to Mr. Neilson, engineer, Glasgow, 2 cwt. of Lesmahago coal will produce 1008 cubic feet of gas, allowing four and a half each pound. Mr. Dewy, in a paper in the *Annals of Philosophy*, asserts, that at Liverpool Mr. King considers it good economy to procure 7000 feet from a ton of Wigan Orral coal, making it only 700 feet from 2 cwt., or very little more than 3 feet per pound. He has stated also, that, at Glasgow, 1200 feet are procured from 2 cwt. of cannel-coal, which is considerably above that mentioned by Mr. Neilson. From these various statements, the general conclusion has been drawn, that 2 cwt. of good coal ought to yield about 1000 feet of gas.

Carburetted hydrogen gas may be procured from a variety of substances. The Wall's End coals appear best fitted for the purpose; but we may briefly give the result of some very interesting experiments made in the laboratory of the Royal Institution with a variety of bodies.

1. The retort was charged with four pounds of coal. The quantity of gas amounted, after having passed the purifiers, to twenty cubic feet. The coke remaining in the retort weighed 2 lbs. 8.7 ozs.

The heating power of the gas flame was compared with that of a wax candle, by ascertaining the time required by each to raise two ounces of water, in a thin copper vessel, from 55° to 212°. The flames were made as similar in dimensions as possible, and so placed that their joints just touched the bottom of the vessel. The heating power of the candle being assumed as = 1, that of the coal gas flame was = 1.5.

2. Four pounds of the dried wood of the common willow yielded sixteen cubical feet of gas, and fourteen ounces of charcoal remained in the retort. The gas burned with a very pale blue flame, was unfit for the purpose of illumination, and contained no olefiant gas.

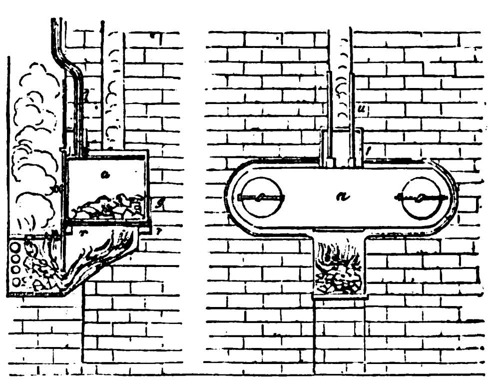
3. Four pounds of the wood of the mountain ash afforded fifteen cubical feet and a half of gas, and thirteen ounces and a half of charcoal. The flame was very pale and blue.

4. Four pounds of white birch-wood gave fourteen cubical feet of gas, and twelve ounces of charcoal. The flame similar to 2 and 3.

5. Four pounds of hazel-wood yielded thirteen cubical feet and a half of gas, and twelve ounces and a half of charcoal. Its heating power was = 1.2. It burned with a better flame than 2, 3, and 4; but the intensity was not sufficient for any useful purpose of illumination.

6. Four pounds of writing-paper gave eighteen cubical feet of gas; and the remaining charcoal, which beautifully retained the form and texture of the paper, weighed eleven ounces and a half. The heating power of the gas was = 1.6. It burned with a flame nearly approaching in illuminating power to that of coal gas.

These experiments, along with others which it is thought unnecessary to notice, prove that the gas from woods is not fit for the purposes of illumination.



In the above wood-cut a representation is given of a domestic gas apparatus, for the generation of gas, which will fully illustrate the general process. If the gas is to be made from resin, a quantity of coke, or even broken bricks, are first introduced into the box *a*. This is intended merely to increase the heated surface within the box. The fire is then lighted in the grate in the ordinary way, as it may

be employed for cooking or heating the apartment while the process is going on. A portion of the heated air and flame passes into the chamber *r*, and as such beneath the box *a*; it then proceeds up the flue *u*. The melted resin passes down the tube *f*, and proceeds direct to the gasometer by the other tube placed by its side.

If, instead of resin, it be advisable to employ coal for producing the gas, it will be necessary to remove the circular caps of iron each time the retort is charged. The trouble also of purifying the gas is considerable, so that for domestic purposes, or in a small establishment, it is most advisable to employ the resin or oil. The decomposition of oil is in fact no more than what we are constantly doing in the common lamp, which owes its light and heat to the application of flame to the wick, which afterwards serves to elevate new portions by capillary attraction, each succeeding portion being decomposed by the flame with which it is brought in contact.

In the *Plate* Gas-Lighting, we furnish a graphic illustration of the interior of a large gas-works, with the men engaged in charging the retorts, &c. The smoke and vapour issuing from the various furnaces and heated coke effectually prevent objects being distinguished at any considerable distance from the observer; so that the glare from the furnaces is thus rendered still more terrific. The small pipes serve to convey the gas to the great iron main leading to the purifying apparatus.

Mr. Taylor contrived a very compact apparatus for generating gas from oil; but, owing to the expense of the material, it has never been very generally adopted.

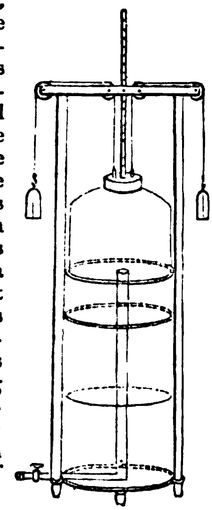
The apparatus for generating gas from common resin is shown at the top of the same plate. The resin, mixed with a little turpentine, is placed in the upper vessel, *a*, and the waste heat from the chimney serves to reduce it to a semi-fluid state. This vessel is divided into two portions by a wire-gauze screen at *b*, through which the melted resin percolates to *c*, so that it may be drawn off at the stop-cock. Here it is received by a funnel, and, descending by the syphon, enters the retort, *d*. The decomposition of the resin is effected before it reaches the condensing vessel, *e*. The condenser serves to retain the turpentine which is not acted upon, and the permanently elastic gas passes along by the pipe *f*, and is conveyed to the gasometer by the pipe *h*.

The turpentine is all collected in the tanks at *g* and *i*, and may be employed any number of times.

An apparatus similar to that now described was employed in the London Institution; and the Editor is enabled to state, from his own observation, that one hundred weight of brown resin usually produced about 1200 feet of gas, which required no subsequent purification.

Gasometer; an instrument for containing gas, which might with more propriety be called a *gas-holder*. One of the most simple gasometers is represented in the accompanying cut. It is made of tinned iron, the surfaces of which are japanned, and consists of two principal parts—a vessel, somewhat bell-shaped, which is designed to contain the gas, and a cylindrical vessel of rather greater depth, in which the former is placed, and which is designed to contain the water by which the gas is confined.

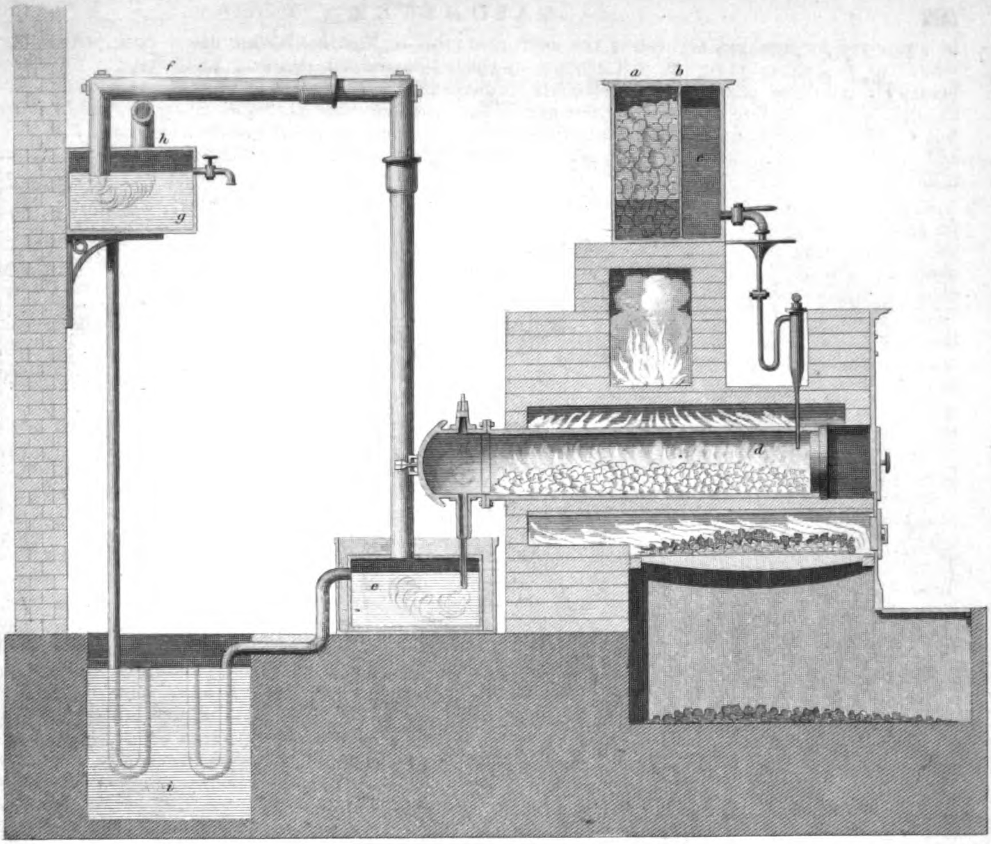
To diminish, however, the quantity of water, this cylindrical vessel has a cone within it, also of japanned tinned iron, adapted to the shape of the gas-holder, so that this latter, when pushed down, slides between this and the cylindrical vessel, and a small quantity of water fills up the space between them. The vessel designed to contain the gas is suspended by cords hung over pulleys, to which weights are attached, so as to counterpoise it. From a stop-cock at the under part of the apparatus, there runs a tube under the cylinder, which rises and passes through the cone, the opening by which it passes being soldered so as to be air-tight: it terminates by an open mouth at the upper part of the bell-shaped iron vessel. This tube, at the part where

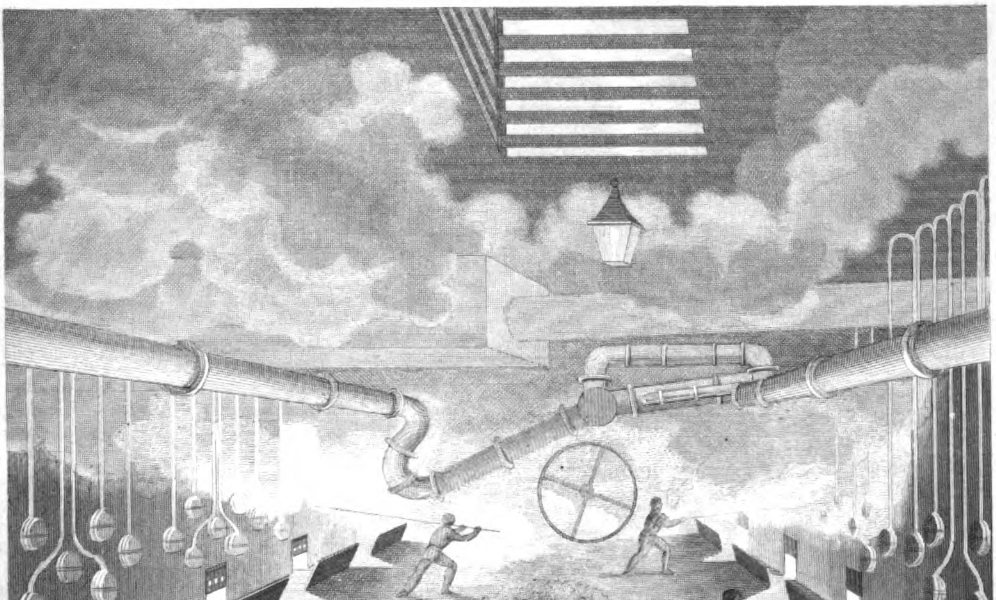


it is bent at right angles, to ascend as has been described, is, in some cases, connected with another, which also runs under the bottom, and ascends on the outside, terminating in a stop-cock; so that from the one stop-cock to the other through the gas-holder, there is an uninterrupted passage. When the instrument is to be used, the stop-cock is opened, and the vessel pressed down; a sufficient quantity of water being in the outer cylinder, the air of the vessel is forced out by the pressure, and its place is occupied by the water in which it is thus immersed. When this is effected, the stop-cock is closed; and now, if we wish to introduce any gas into the apparatus, a bent funnel, the mouth of which is placed in a vessel of water, is attached to the tube of the second stop-cock, and this stop-cock is opened. If the extremity of a retort, or of a tube, conveying gas, terminate below the orifice of the funnel, the gas will rise along the tube, and will ascend to the top of the gas-holder, and this, being counterpoised, will, as the gas enters, rise in the water, until it is filled, a quantity of water remaining around the mouth of it, by which the air is confined. When the gas is to be expelled, the second stop-cock is closed, and the other opened, a flexible tube is adapted to it, and the gas-holder being pressed down, either by the hand or by its own weight from the removal of the counterpoising weights, a stream of gas issues from the extremity of a flexible tube, and may be transferred into a jar, or be applied to any other purpose, and its quantity may be measured by the instrument being graduated by a scale marked on a brass rod.

For experiments on gases which require much accuracy, mercury must be substituted for water, and the internal cone, to which we have alluded, then becomes valuable on the score of economy. The experiments may be performed by means of it on a tolerably large scale, although the necessary quantity of mercury to fill the gasometer, &c., is comparatively small. The mercurial apparatus, however, is too costly, and too easily put out of order, to be accepted with welcome among the generality of the cultivators of chemical science.

GAS MANUFACTURE.

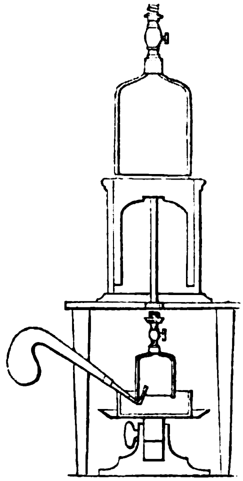




INTERIOR OF A GAS HOUSE.

Drawn by Charles Blunt. London Published by William Orr Paternoster Row. Sept. 1835. Engraved by J. Dower.

Beneath is a representation of the bell of the gasometer, made of glass, furnished with a cock at the top, and able to contain 34 ounces Troy of distilled water. The divisions of capacity, determined by actual measurement, are marked on the glass. Still lower is a section of two cylinders of cast-iron, the outward one screwed upon the solid internal one, which is made to project at its lower extremity, and furnished with a male screw, to work into a female screw with which the lower end of the external cylinder is furnished. The space between these is so adjusted as to be almost filled up by the substance of the glass bell when dropped into it, so that the quantity of mercury necessary to fill up that space is proportionally small. The internal cylinder has a conducting tube up through its axis, the lower end of which is furnished with a female screw answering to the male screw of the cock of the small receiver. This receiver is made of glass, and open at bottom. When used, it is screwed into its place, and rests upon a small cup or cistern of mercury, in which the beak of a retort, furnished with a bent glass tube, may be introduced under the receiver. At the bottom is a section of a wooden stand upon which the cast-iron cylinders are supported, having an opening through the top to permit the cock of the receiver to be joined to the conducting tube of the internal iron cylinder. The cistern is adjusted to hold a given quantity of air.



GASKET; a sort of plaited cord, fastened to the sail-yards of a ship, and used to furl or tie up the sail firmly to the yard by wrapping it round both.

GASTRIC; that which relates to digestion.

GASTRIC JUICE; a fluid of the utmost importance in the process of digestion. It does not act indiscriminately on all substances; nor is it the same in all animals; nor does it continue always of the same nature, even in the same animal, changing according to circumstances. It acts with a chemical energy in dissolving food; attacking the surface of bodies, and uniting to the particles of them. It operates with more energy and rapidity the more the food is divided; and its action is increased by a warm temperature. The food is not merely reduced to very minute parts; its taste and smell are quite changed; its sensible properties are destroyed; and it acquires new and very different ones. This fluid does not act as a ferment; it is a powerful antiseptic, and even restores flesh already putrefied.

GASTRIC SYSTEM comprehends all the parts of the body which contribute to digestion. *Gastric disorders* are those in which the digestion particularly is deranged. As the precepts of health, with regard to eating and drinking, are so often transgressed, the quality of the food itself often bad, the gastric system composed of many parts, and much affected by the influence of the external temperature, gastric disorders must necessarily be frequent. Their symptoms are, want of appetite, a bitter and disagreeable taste, a furred tongue, frequent and unpleasant rising from the stomach, a sense of weight and oppression in the stomach, looseness or costiveness, &c. From the close connection of the organs of digestion with the other parts of the body, gastric disorders are often combined with others, as with fever.

GASTRONOMY; the science of eating and drinking. The gastronomy of the Romans was the most gross and luxurious, as that of the French is the most refined and delicate, combined with the rules of health and social merriment. (See the Paris *Almanach des Gourmands*. The new series, from 1825, contains songs by Béranger and others.)

GAUZE, in *commerce;* a thin, transparent stuff, sometimes woven of silk, and sometimes of thread and worsted. Gauzes are either plain or figured. The latter are worked with flowers of silver or gold on a silk ground, and are chiefly imported from China. Gauzes of excellent quality have, of late years, been manufactured at Paisley.

GELATINE, in *chemistry,* is one of the constituent parts of animal substances, and may be obtained by repeatedly washing the fresh skin of an animal in cold water, afterwards boiling it, and reducing it to a small quantity by slow evaporation, and allowing it to cool. It then assumes the form of jelly, and becomes hard and semi-transparent. It is a principal ingredient both of the solid and fluid parts of animals, and is employed in the state of glue, size, and isinglass.

Gelatine is used in a new kind of bread, called *pain animalisé,* now manufactured in Paris. It having been found that the gelatine of bones used for soups was exceedingly nutritious, it was imagined that if this gelatine could be introduced into bread from potato flour, which is much less nutritious than wheaten flour, the former would be equally pleasant, and even more nutritive than wheaten bread. The experiment has been tried with great success; and beautiful loaves of bread, made in this way, are now sold in Paris at a much lower price than bread from wheat flour. The gelatine is so purified as to impart no unpleasant flavour, and the potato bread, thus manufactured, is as agreeable as it is wholesome. As a cheap, nutritious, and useful article of food for the poor, the potato bread thus made is unequalled. A large quantity of the biscuit sent out with the African expedition to Algiers was prepared in this way.

GEMS, or PRECIOUS STONES, are sometimes found of regular shapes and with a natural polish, and sometimes of irregular shapes and with a rough coat. The first sort may be considered as of the pebble kind, and are said to be found near the beds of rivers, after great rains; the others are found in mines, and in the clefts of rocks. The gems of the first sort were what the ancients most usually engraved upon. These are commonly called *intaglios;* and they are mostly of a long, oval figure, inclining to a point at each end, convex as well on the engraved face as on the others, with a ridge running from end to end on the under side, which is hereby, as it were, divided into two faces; both which are also, though not so distinctly, parted from the upper face by another ridge running quite round the oval.

The stone most commonly found engraved is the beryl. The next is the emerald; and then the jacinth. The chrysolite is very rarely found engraved, as are also the crystal, or Oriental pebble, the garnet,

and the amethyst. The following is a general list of what are usually called *precious stones:*—the beryl, red, yellow, or white; emerald, green; jacinth, of a deep tawny red; chrysolite, of a light grass-green; crystal, or Oriental pebble, of a silvery white; garnet, of a deep red claret colour; amethyst, purple; diamond, white; ruby, red or crimson-coloured; emerald, of a deep green; aqua marina, of a bluish sea-green, like sea-water; topaz, of a ripe citron yellow; sapphire, of a deep sky-blue, or of a silver white; cornelian, red or white; opal, white and changeable; vermilion-stone, more tawny than the jacinth. All these stones are more or less transparent. The following are all opaque:—the cat's eye, brown; red jasper, called also *thick cornelian*, of the colour of red ochre; jet, black; agates of various sorts; blood-stone, green, veined or spotted with red and white; onyx, consisting of different parallel strata, mostly white and black; sardonyx, of several shades of brown and white; agate-onyx, of two or more strata of white, either opaque or transparent; alabaster, different strata of white and yellow, like the agate-onyx, but all opaque; toad's eye, black; turquoise, of a yellowish blue, inclining to green; lapis-lazuli, of a fine deep blue. Of most of the species beforementioned, there are some of an inferior class and beauty. These are commonly called, by jewellers, *Occidental stones*. They are mostly the produce of Europe, and found in mines or stone quarries; and are so named in opposition to those of a higher class, which are always accounted Oriental, and supposed to be produced only in the East.

The onyx, sardonyx, agate-onyx, alabaster of two colours or strata, as also certain shells of different coats, were frequently engraved, by the ancients, in relief; and these sorts of engravings are commonly called *cameos*. They also sometimes ingrafted a head, or some other figure in relief, of gold, upon a blood-stone. Besides which there are some antiques, mostly cornelians, that are covered with a stratum of white. This stratum has by some been looked upon as natural, but it was really a sort of coat of enamel that was laid on, in the same way as two surfaces of glass are made to adhere by the aid of heat in the beautiful incrustations of the present day. The ancients engraved most of their stones, except the onyx and the sardonyx, just as they were found; their natural polish excelling all that can be given by art; but the beauty of the several species of onyx could be discovered only by cutting. The merit of intaglios and cameos depends on their *erudition*, as it is termed, or the goodness of the workmanship, and the beauty of their polish.

The antique Greek gems are most esteemed; and, next to them, the Roman ones of the times of the higher empire. Lapidaries employ a considerable quantity of diamond in powder, which they use with steel instruments, to divide pebbles and precious stones. The small pieces of diamond, of which the powder is made, are worth 28 shillings a carat. The use of the diamond in this way is very extensive. Had nature withheld the diamond, the pebble, the agate, and a variety of other stones, would have been of little value, as no other substance is hard enough to operate upon them. In this way, rock crystal, from Brazil, is divided into leaves, and ground and polished with diamond dust for spectacles and other optical instruments.

The great value of the precious stones has led to artificial imitations of their colour and lustre, by compositions in glass. In order to approximate as near as possible to the brilliancy and refractive power of native gems, a basis, called a *paste*, is made from the finest flint glass, composed of selected materials, combined in different proportions, according to the preference of the manufacturer. This is mixed with metallic oxides capable of producing the desired colour. A great number of complex processes are in use among manufacturers of these articles.

A method is sometimes resorted to for taking the impressions and figures of antique gems, with their engravings, in glass, of the colour of the original gem. Great care is necessary in the operation, to take the impression of the gem in a very fine earth, and to press down upon this a piece of proper glass, softened or half melted at the fire, so that the figures of the impression made in the earth may be nicely and perfectly expressed upon the glass. The yellowish tripoli has been found best adapted for this purpose.

GEM-SCULPTURE; the glyptic art, or lithoglyptics; the art of representing designs upon precious stones, either in raised work (*cameos*), or by figures cut into or below the surface (*intaglios*). The former method may have been practised at a very early period, and probably had its origin with the Babylonians, who worshipped the heavenly bodies, and were accustomed to wear figured talismans, which served as symbols of their influences. From them the custom of wearing engraved stones passed to the Hebrews. According to others, this art originated in India. The Egyptians cut the hardest kinds of stones. The custom of wearing cut stones as seal rings appears to have been general among the Greeks in the time of Solon. One of the earliest artists in this branch of whom mention is made is Mnesarchus, the father of the philosopher Pythagoras, consequently a contemporary of that Theodorus of Samos who engraved the ring of Polycrates, of which such wonderful stories are told by the ancients. These ancient works were probably *intaglios;* the artist made use of the lathe, the *maxium*, the *ostracitis*, the diamond point, and diamond powder.

Whether the Egyptian *scarabæi*, of which many specimens are seen in the British Museum, and the Græco-Etruscan imitations of them, are the most ancient specimens of this interesting art, may be doubted on account of the form of the stones (cut into the shape of beetles). Yet the specimens of the early period of the art are so rare, that we have not sufficient data for fixing on any class as prior to that just mentioned. The flourishing period of the *glyptic art* seems to have been the age of Alexander the Great; but we are able to judge of the works of Pyrgoteles, Apollonides, and Cronius only from tradition, as there are no works of these masters extant. Pyrgoteles was distinguished for works in relief; and from his time the art may have risen, gradually, to that degree of perfection of which we possess such rich specimens. The artists, some of whose names we learn from their works themselves (of whom Gr. Clarac has given a list in his *Description des Antiques du Musée Royal de France*, Paris, 1820), took the master-pieces of sculpture for their subjects and models. Under the Roman emperors, in particular, this was very common.

The names of Dioscorides, Apollonides, Aulos, Hyllos, Cneius, Solon, remind us of the most perfect works in this branch of art. But the works of greatest

value which have come down to us—the onyx, in the chapel at Paris, the apotheosis of Augustus in Vienna, the onyx, at the Hague, representing the apotheosis of the emperor Claudius, Achilles lamenting Patroclus, the head of Julius Cæsar—these, and the Brunswick vase, and the Trivulcian and Neapolitan cups, bear no distinguished names.

Names of Greek composition were frequently put on engraved stones in the fifteenth century, when the patronage of the Medici revived the taste for gems and dactyliothecæ, which had so powerfully promoted this branch of art under the later Roman emperors. Pompey consecrated the dactyliotheca of Mithridates, as a votive offering, in the capitol; Julius Cæsar, six tablets, with six gems, in the temple of Venus. At a later period, the collections of Herodes Atticus, of Vespasian, &c., were celebrated; yet this general taste was not able to preserve the art from decline. We find proofs of this degeneracy in the times of the later emperors, in the numerous class of gems called *abraxas* and *abraxides*, in some rare works of the Byzantine period, and in some artificial gems at an early period of the Christian era. From the time of Gallienus, these marks of degeneracy are particularly striking. As no use could be made of the material of these works, gems continued to be highly prized, even in the times of the greatest barbarism, and served to ornament the shrines of saints, royal badges, and ceremonial dresses, and thus passed safely through the ages of destruction and ignorance, in which the finest statues were valued as materials for mortar or for building, down to ages which could appreciate their value.

If we may judge from the remains which have come down to us, engraved gems seem to have been more common in Byzantium and Constantinople than in the West. The stone with the head of Richilde, the wife of Charles the Bold, is a relic of a period of which hardly any other works of art remain, except, perhaps, a few on religious subjects. The earliest gem-engraver of modern times is Vittore Pisanello, who lived at Florence about the year 1406. Among the Germans, Daniel Engelhard, of Nuremberg, was the earliest. He died in 1512. The discovery of some fine specimens in Italy, particularly at Florence, and the display of gems by the emperor Palæologus, at the council of Florence, in 1438, were perhaps the original cause of the taste of the Medici for engraved stones. The popes and that family were the first patrons of this art in modern times.

A Florentine artist, by the name of *John* (generally called, on account of his great skill, *Giovanni delle Corniole*), distinguished himself in this early period of the modern art. There are but few gems which can be ascribed to him, with any confidence, besides the famous cornelian in the Florentine museum, with the portrait of Savonarola, bearing the inscription *Hieronymus Ferrariensis ordinis prædicatorum, propheta, vir et martyr*. This stone, which must have been engraved later than 1498, is given in *Agincourt's Sculpture* (tab. 48, number 82). Contemporaries and rivals of Giovanni were Nanni di Prospero dalle Carniole, in Florence, whom Francesco Salviati directed in his works, and Domenico Compagnie (*dei camei*), a Milanese, whose portrait of Ludovico Sforza, called *Moro*, cut in a ruby, is still preserved in the Florentine museum. After Bernardi (*delle Corniole*), Valerio Vicentino (under Leo X.) rendered himself famous as a gem-engraver.

This art found patrons in all the Italian princes; the number of artists constantly increased, and the sphere of their art was extended. The names of the artists, however, are not generally known, because they were rarely put upon the stones. Many gems, too, are still concealed in the cabinets of the wealthy or the treasuries of princes. Until these are as accurately described as those of the Ambrosian collection, it will be difficult to obtain a complete general view. Subjects of antiquity were treated by these artists in preference, and with such ability that it often requires the skill of the most accomplished connoisseur to distinguish them from genuine antiques. The dispute concerning the famous seal ring of Michael Angelo is well known. It is not improbable that this cornelian is the work of Pietro Maria de Pescia, as the figure of the fisherman in the exergue may indicate that artist, who, with Michelino, belonged to the age of Leo X.—(Fiorillo, *Essays* vol. ii., page 188.)

In order to give the gems more completely the appearance of antiques, some artists engraved their names in Greek, but with so little knowledge of the language that they sometimes betrayed themselves by this artifice. To this time we must ascribe the gems with the name *Pyrgoteles*, which Fiorillo endeavours to prove were the works of an Italian of Greek descent (Lascaris). The art of engraving was also applied to glass and gold. The crystal box of Valerio Belli, the most skilful and industrious artist in this branch during the 16th century, deserves particular mention. It was intended by Clement VII. as a present to Francis I., when Catherine of Medici went to Marseilles in 1533. At present it is in Florence. Drawings of it are to be found in *Agincourt's Sculpture* (table 43) and in *Cicognara* (ii., table 87).

The Milanese particularly distinguished themselves, as the wealth of the principal citizens of Milan enabled them to patronise this art. Jacopo de Trezza—the same artist who, in 1564, executed for Philip II. the famous tabernacle of the Escurial—made the first attempts at engraving on the diamond, in Milan. The greatest cameo work of modern times is the stone in the Florentine museum, seven inches in breadth, upon which Cosmo, Grand Duke of Tuscany, with his wife Eleonore and seven children, are represented. A Milanese, John Anthony de Rossi, who was a contemporary of the Saracchi family (about 1570), is the artist. The Saracchi were five brothers, and the crystal helmet of Albert of Bavaria is a proof of their skill.

The first traces of gem-engraving in Germany are found in the 14th and 15th centuries, in Nuremberg and Strasburg. Natter, himself a distinguished artist in this branch, has given an account of his predecessors in his *Traité de la Méthode Antique de graver en Pierre Fine, comparée avec la Méthode Moderne* (London, 1755). Natter himself, Pichler, and Marchant, are considered as the restorers of this art in that country. Facius and Hecker are also esteemed. It is still practised with great success by several artists, and by Polish Jews with particular skill, but only for coats of arms. France and England have not produced any first-rate gem-engravers. The most distinguished artist of the age is, perhaps, Berini, a native of Rome, now at Milan, who, with Cervara and Giromelli, at Rome, and Putinati, at Milan, has produced the finest works in recent times.

GENERAL, in *military affairs;* he who commands in chief.

General is also used for a particular march or beat of drum, being the first which gives notice for the infantry to be in readiness to march.

GENERATED is used by mathematicians to denote whatever is formed by the motion of a point, line, or surface. Thus a line is said to be *generated* by the motion of a point; a surface, by the motion of a line; and a solid, by the motion of a surface. The same term is also sometimes used in a similar sense in arithmetic and algebra. Thus 20 is said to be generated by the two factors 4 and 5, or 2 and 10; $a\,b$, of the factors a and b, &c.

GENERATOR. See STEAM-ENGINE.

GENEVA, or GIN; a hot, fiery spirit, much used by the lower classes of people as a dram, and unquestionably as injurious to their bodily health as to their moral character. A liquid of this kind was formerly sold in the apothecaries' shops, drawn from the juniper-berry; but distillers have now completely supplanted the trade of the apothecary, and sell it under the name of *geneva* or *gin*, of which, it is believed, juniper-berries make no part of the composition. It is usually composed of malt and other spirits. A better sort is said to be drawn off, by a slow fire, from juniper-berries, proof-spirits, and water, in the proportion of three pounds of berries to four gallons of water and ten of spirit. The celebrated Holland geneva is manufactured chiefly at a village near Rotterdam, from the same materials, French brandy being used instead of malt spirits.

GENS D'ARMES; the name originally given in France to the whole body of armed men *(gens armata)*, but, after the introduction of standing armies, to a body of heavy-armed cavalry, which composed the chief strength of the forces, and was provided with helmets, cuirasses, pistols, horses protected with armour, &c. After the time of Louis XIV. they had only pistols, helmets, and swords. Part of them were under the immediate orders of the king, part composed the first body of the French cavalry. The latter consisted of men of rank, and belonged to the troops of the royal household. At the revolution this body was broken up. The name *gens d'armes* has since been given to a corps which succeeded the former *(maréchaussée)*, employed in the protection of the streets. It was composed of infantry and cavalry, and belonged to the military, but served principally to enforce the police regulations.

Under Napoleon it was a distinction to serve in this corps, because only veterans were employed in it; but the members were hated in a high degree, because they had to execute so many odious orders. When the German nations rose against Napoleon, *gens d'armes* were killed wherever they were found. The Bourbons retained this corps; and they are said to have behaved generally with great moderation; yet the people continued to hate them as the instruments of tyranny. On one occasion, however,—the massacre of the Rue St. Denis—they seemed to take revenge for all the insults they had suffered so long. This hastened Villèle's downfal. August 16, 1830, a royal ordinance abolished the gens d'armes, and established a new body called the *municipal guard* of Paris, to consist of 1443 men, under the direction of the prefect of police.

GEOCENTRIC; what relates to the centre of the earth, or is considered as if from the centre of the earth. (See HELIOCENTRIC.)

GEOCYCLIC MACHINE; a machine intended to represent in what manner the changes of the seasons, the increase and decrease of the days, &c., are caused by the inclination of the axis of the earth to the plane of the ecliptic, at an angle of 66½ degrees, and how the axis, by remaining parallel to itself in all points of its path round the sun, invariably preserves this inclination.

GEOMETRY (from the Greek, signifying the *art of measuring land*); the branch of pure mathematics which treats of the magnitudes of dimensions. It is divided into *longimetry*, occupied exclusively with lines, *planimetry*, occupied with planes or surfaces, and *stereometry*, treating of solid bodies, their contents, &c., and the doctrine of the functions of the circle, and its application to certain figures, formed by lines, from which originate (*a.*) *trigonometry*, (*b.*) *tetragonometry*, (*c.*) *polygonometry*, (*d.*) *cyclometry*, which teach us to find, from the dimensions of certain parts of a figure, those of certain other parts, by which particular altitudes and depths are to be measured.

Geometry is divided into *elementary* and *applied*. The former, or theoretical geometry, treats of the different properties and relations of the magnitudes of dimension in theorems and demonstrations, which the latter applies to the various purposes of life in problems and solutions. Geometry is taught in different ways; as, for instance, by diagrams, which is called *constructive geometry*, or by the application of algebra to dimension, which is called *analytical geometry*.

The invention of this important science is ascribed by some to the Chaldæans and Babylonians; by others to the Egyptians, who were obliged to determine the boundaries of their fields, after the inundation of the Nile, by geometrical measurements. According to Cassiodorus, the Egyptians either derived the art from the Babylonians, or invented it after it was known to them. Thales, a Phœnician who died 548 B. C., and Pythagoras of Samos, who flourished about 520 B. C., introduced it from Egypt into Greece. The discovery of five regular geometrical bodies, the *cube*, *tetraedron*, *octaedron*, *icosaedron*, and *dodecaedron*, is ascribed to the latter. He distinguished himself particularly by the invention of the theorem which is called from him the *Pythagorean*, and, on account of his important improvements, has received the name of *magister matheseos*.

In elementary geometry, Euclid of Alexandria is particularly distinguished. About a hundred years after him, Archimedes extended the limits of geometry by his measure of the sphere and the circle. Aristæus, and, at a later period, Apollonius of Perga (who flourished 260—230 B. C.), did much for the higher geometry. In Italy, where the sciences first revived after the dark ages, several mathematicians were distinguished in the 16th century; the French, and particularly the Germans, followed. Justus Byrge laid the foundation of logarithms, and, according to some, was the inventor of the proportional circle; others ascribe the invention to Galileo. Reinerus Gemma Frisius, who died in 1555, invented the instrument used in surveying, called the *plain table*. Simon Stevin of Bruges applied the decimal measure to geometry.

In 1635, Bonaventus Carallieri opened the path to the higher geometry of infinites; and, in 1684, Leibnitz advanced the science by the invention of the

differential calculus, and Newton by the theory of the fluxions. Robert Hook, who died in 1703, was the first who considered the influence of the refraction of light in measuring heights. Ludolph of Ceuln, or Cologne, who died at Leyden in 1610, discovered the proportion between the diameter and the circumference of the circle. In recent times, the French have been most distinguished in geometry, and have produced the best elementary works for schools in this branch; as, for instance, those of Legendre and Mongé. The Germans have a number of elementary works on geometry, some of which are excellent. Among the most approved modern works on the elements of geometry are those of Euclid, as translated by Simson, Ingram, and Playfair, and the treatises of Professor Leslie, and M. Legendre.

From a perusal of the above history of the progress of geometrical science, it must be evident that any attempt at a complete consecutive treatise on the subject would swell the present article to a most inconvenient length, and indeed that it would be completely incompatible with the general arrangement of the work. We purpose, therefore, confining ourselves to a series of useful definitions, which may be said to form the alphabet of the science. Problems illustrative of the application of geometry to the useful arts will be found under the various articles which need mathematical illustration.

A *point* has neither length, breadth, nor thickness. From this definition it may easily be understood that a mathematical point cannot be seen nor felt; it can only be imagined. What is commonly called a point, as a small dot made with a pencil or pen, or the point of a needle, is not in reality a mathematical point; for, however small such a dot may be, yet, if it be examined with a magnifying glass, it will be found to be an irregular spot, of a very sensible length and breadth; and our not being able to measure its dimensions with the naked eye arises only from its smallness. The same reasoning may be applied to every thing that is usually called a point, as even the point of the finest needle appears like that of a poker when examined with the microscope.

A *line* is length, without breadth or thickness.—What was said above of a point is also applicable to the definition of a line. What is drawn upon paper with a pencil or pen is not, in fact, a line, but the representation of a line. For, however fine you may make these representations, they will still have some breadth. But, by the definition, a line has no breadth whatever; yet it is impossible to draw any thing so fine as to have no breadth. A line, therefore, can only be imagined. The ends of a line are points.

Parallel lines are such as always keep at the same distance from each other, and which, if prolonged ever so far, would never meet. (See *fig.* 1.)

Fig. 3.

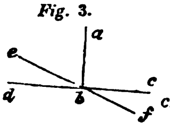


Fig. 2.

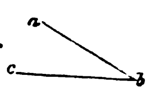
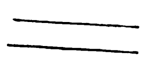


Fig. 1.



A *right line* is what is commonly called a *straight* line, or one that tends every where the same way.

A *curve* is a line which continually changes its direction between its extreme points.

An *angle* is the inclination or opening of two lines meeting in a point. (*Fig.* 2.)

The lines *a b*, and *b c*, which form the angle, are called the legs or sides; and the point *b*, where they meet, is called the *vertex* of the angle, or the *angular point*. An angle is sometimes expressed by a letter placed at the vertex, as the angle *b*, *fig.* 2; but most commonly by three letters, observing to place in the middle the letter at the vertex, and the other two at the end of each leg, as the angle *a b c*.

When one line stands upon another, so as not to lean more to one side than to another, both the angles which it makes with the other are called *right angles*, as the angles *a b c* and *a b d*, *fig.* 3; and all right angles are equal to each other, being all equal to 90°; and the line *a b* is said to be *perpendicular* to *c d*.

Beginners are very apt to confound the terms *perpendicular* and *plumb* or *vertical line*. A line is vertical when it is at right angles to the plane of the horizon, or level surface of the earth, or to the surface of water, which is always level. The sides of a house are vertical. But a line may be perpendicular to another, whether it stands upright or inclines to the ground, or even if it lies flat upon it, provided only that it makes the two angles formed by meeting with the other line equal to each other; as, for instance, if the angles *a b c* and *a b d* be equal, the line *a b* is perpendicular to *c d*, whatever may be its position in other respects.

When one line, *b e* (*fig.* 3), stands upon another, *c d*, so as to incline, the angle *e b c*, which is greater than a right angle, is called an *obtuse* angle; and that which is less than a right angle is called an *acute* angle, as the angle *e b d*.

Two angles which have one leg in common, as the angles *a b c*, and *a b e*, are called *contiguous* angles, or *adjoining* angles; those which are produced by the crossing of two lines, as the angles *e b d* and *c b f*, formed by *c d* and *e f* crossing each other, are called *opposite* or *vertical* angles.

A *figure* is a bounded space, and is either a *surface* or a *solid*.

A *superficies*, or *surface*, has length and breadth only. The extremities of a superficies are lines.

A *plane*, or *plane surface*, is that which is every where perfectly flat and even, or which will touch every part of a straight line, in whatever direction it may be laid upon it. The top of a marble slab, for instance, is an example of this, which a straight-edge will touch in every point, so that you cannot see light any where between. Water furnishes another striking example of what is termed a plane surface, although strictly speaking it is a curved one, as the effects of gravity must in every case produce a rounding of the upper side.

A *curved surface* is that which will not coincide with a straight line in any part. Curved surfaces may be either convex or concave.

A *convex surface* is when the surface rises up in the middle, as, for instance, a part of the outside of a globe.

A *concave surface* is when it sinks in the middle, or is hollow, and is the reverse of convex.

A surface may be bounded either by straight lines, curved lines, or both these.

Every surface bounded by straight lines only is called a *rectilinear figure*.

Three is the fewest number of sides that a rectilinear figure can have, and it is then called a *triangle*.

Triangles are of different kinds, according to the *lengths of their sides*.

An *equilateral triangle* has all its sides equal, as *a b c*, *fig.* 4.

Fig. 7.

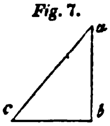
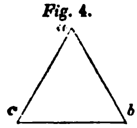


Fig. 5.

Fig. 6.

Fig. 4.



An *isosceles triangle* has two equal sides, as *d e f*, *fig.* 5.

A *scalene triangle* has all its sides unequal, as *g h i*, *fig.* 6.

Triangles are also denominated according to the *angles they contain.*

A *right-angled* triangle is one that has in it a right angle, as *a b c*, *fig.* 7.

A triangle cannot have more than one right-angle. The side opposite to the right-angle *b*, as *a c*, is called the *hypothenuse*, and is always the longest side.

An *obtuse-angled* triangle has one obtuse angle, as *fig.* 8.

Fig. 11.

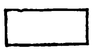


Fig. 10.

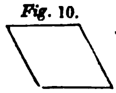
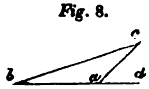


Fig. 9.

Fig. 8.



An *acute-angled* triangle has all its angles acute, as *fig.* 4.

An isosceles, or a scalene triangle, may be either right-angled, obtuse, or acute.

Any side of a triangle is said to *subtend* the angle opposite to it; thus *a b*, *fig.* 7, subtends the angle *a c b*.

If the side of a triangle be drawn out beyond the figure, as *a d* (*fig.* 8), the angle *a*, or *c a b*, is called an *internal* angle, and the angle *c a d*, or that without the figure, an *external* angle.

Figures with four sides are called *quadrilateral* figures. They are of various denominations, as their sides are equal or unequal, or as all their angles are right angles or not.

Every four-sided figure whose opposite sides are parallel is called a *parallelogram*. Provided that the sides opposite to each other be parallel, it is immaterial whether the angles are right or not. *Fig.* 9, 10, 11, and 12, are all parallelograms.

Fig. 15.

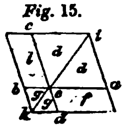


Fig. 14.

Fig. 13.

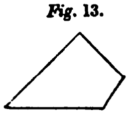
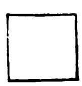


Fig. 12.



When the angles of a parallelogram are all right angles, it is called a *rectangular parallelogram*, or a *rectangle*, as *fig.* 11 and 12.

A rectangle may have all its sides equal, or only the opposite sides equal. When all its sides are equal, it is called a *square*, as *fig.* 12.

When the opposite sides are parallel, and all the sides equal to each other, but the angles not right angles, the parallelogram is called a *rhombus*, as *fig.* 10.

A parallelogram having all its angles oblique, and only its opposite sides equal, is called a *rhomboid*, as *fig.* 9.

When a quadrilateral or four-sided figure has none of its sides parallel, it is called a *trapezium*, as *fig.* 13; consequently every quadrangle or quadrilateral which is not a parallelogram is a trapezium.

A *trapezoid* has only one pair of its sides parallel, as *fig.* 14.

A *diagonal* is a right line drawn between any two angles that are opposite in a quadrangle, as *i k*, *fig.* 15. In parallelograms the diagonal is sometimes called the *diameter*, because it passes through the centre of the figure.

Complements of a parallelogram. If any point, as *e* (*fig.* 15), be taken in the diagonal of a parallelogram, and through that point two lines are drawn parallel to the sides, as *a b*, *c d*, it will be divided into four parallelograms, *d d*, *l*, *f*, *g g*. The two divisions, *l*, *f*, through which the diameter does not pass, are called the complements.

Figures having more than four sides are called *polygons*. If the sides are all equal, they are called *regular polygons*: if they are unequal, they are called *irregular polygons*.

A pentagon is a polygon of five sides.
A hexagon has six sides.
A heptagon seven sides.
An octagon eight sides.
A nonagon nine sides.
An undecagon eleven sides.
A duodecagon twelve sides.

When they have a greater number of sides, they are called polygons of thirteen sides, of fourteen sides, and so on.

Base of a figure is the side on which it is supposed to stand erect, as *d e* (*fig.* 16).

Fig. 19.

Fig. 18.

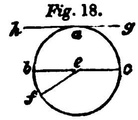


Fig. 17.

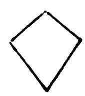
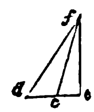


Fig. 16.



Altitude of a figure is its perpendicular height from the base to the highest part, as *c f* (*fig.* 16).

Area of a plane figure, or other surface, means the quantity of space contained within its boundaries, expressed in square feet, yards, or any other superficial measure.

Similar figures are such as have the same angles, and whose sides are in the same proportion, as *fig.* 17.

Equal figures are such as have the same area or contents.

A *circle* is a plane figure, bounded by a curve line returning into itself, called its *circumference*, *a b c*, (*fig.* 18), every where equally distant from a point, *e*, within the circle, which is called the *centre*.

The *radius* of a circle is a straight line drawn from the centre to the circumference, as *e f* (*fig.* 18). The radius is the opening of the compass when a circle is described; and consequently all the radii of a circle must be equal to each other.

A *diameter* of a circle is a straight line drawn from one side of the circumference to the other through the centre, as *c b* (*fig.* 18). Every diameter divides the circle into two equal parts.

A *segment* of a circle is a part of a circle cut off by a straight line drawn across it. This straight line is called the *chord*. A segment may be either equal to, greater, or less, than a *semicircle*, which is a segment formed by the diameter of the circle, as *c e b*, and is equal to half the circle.

A *tangent* is a straight line drawn so as just to touch a circle without cutting it, as *g h* (*fig.* 18). The point *a*, where it touches the circle, is called

the *point of contact*. And a tangent cannot touch a circle in more points than one.

A *sector* of a circle is a space comprehended between two radii and an arc, as *i k* (*fig*. 19).

The circumference of every circle, whether great or small, is supposed to be divided into 360 equal parts, called *degrees;* and every degree into 60 parts, called *minutes;* and every minute into 60 *seconds*. To measure the inclination of lines to each other, or angles, a circle is described round the angular point as a centre, as *i k* (*fig*. 19); and according to the number of degrees, minutes, and seconds, cut off by the sides of the angle, so many degrees, minutes, and seconds, it is said to contain. Degrees are marked by °, minutes by ′, and seconds by ″; thus an angle of 48 degrees, 15 minutes, and 7 seconds, is written in this manner, 48° 15′ 7″.

A *solid* is any body that has length, breadth, and thickness: a book, for instance, is solid—so is a sheet of paper; for, though its thickness is very small, yet it has some thickness. The boundaries of a solid are *surfaces*.

Similar solids are such as are bounded by an equal number of similar planes.

A *prism* is a solid of which the sides are parallelograms, and the two ends or bases are similar polygons, parallel to each other. Prisms are denominated according to the number of angles in the base, *triangular* prisms, *quadrangular*, *pentangular*, and so on, as *fig*. 20, 21, 22, 23.

Fig. 23.

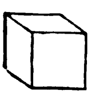


Fig. 22.

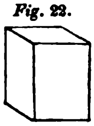


Fig. 21.

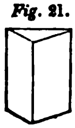
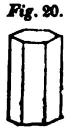


Fig. 20.



If the sides are perpendicular to the plane of the base, it is called an *upright* prism; if they are inclined, it is called an *oblique* prism.

When the base of a prism is a parallelogram, it is called a *parallelopipedon*, as *fig*. 22 and 23. Hence a parallelopipedon is a solid terminated by six parallelograms.

When all the sides of a parallelopipedon are squares, the solid is called a *cube*, as *fig*. 23.

A *rhomboid* is an oblique prism, whose bases are parallelograms.

Fig. 26.

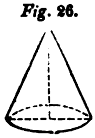


Fig. 25.

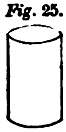
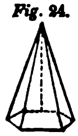


Fig. 24.



A *pyramid* (*fig*. 24) is a solid bounded by, or contained within, a number of planes, whose base may be any rectilinear figure, and whose faces are triangles terminating in one point, commonly called the *summit* or *vertex* of the pyramid.

When the figure of the base is a triangle, it is called a *triangular pyramid;* when the figure of the base is quadrilateral, it is called a *quadrilateral pyramid*, &c.

A pyramid is either *regular* or *irregular*, according as the base is regular or irregular.

A pyramid is also *right* or *upright*, or it is *oblique*. It is *right*, when a line drawn from the vertex to the centre of the base is perpendicular to it, and *oblique* when this line inclines.

A *cylinder* is a solid (*fig*. 25) generated or formed by the rotation of a rectangle about one of its sides, supposed to be at rest; this quiescent side is called the *axis* of the cylinder. Or it may be conceived to be generated by the motion of a circle in a direction perpendicular to its surface, and always parallel to itself.

A cylinder is either *right* or *oblique*, as the axis is perpendicular to the base or inclined.

Every *section* of a right cylinder taken at right angles to its axis is a *circle;* and every section taken across the cylinder, but oblique to the axis, is an *ellipsis*.

As a circle may be considered to be a polygon of an infinite number of sides, so a cylinder may be conceived as a prism having such polygons for bases.

A *cone* is a solid (*fig*. 26), having for its base a circle, and its sides a convex surface, and terminating in a point, called the *vertex* or *apex* of the cone. It may be conceived to be generated by the revolution of a right-angled triangle about its perpendicular.

A line drawn from the vertex to the centre of the base is the *axis* of the cone.

When this line is perpendicular to the base, the cone is called an upright or *right* cone; but, when it is inclined, it is called an *oblique* cone.

If a cone be cut through the axis from the vertex to the base, the section will be a *triangle*.

If a right cone be cut by a plane at right angles to the axis, the section will be a *circle*.

If a cone be cut oblique to the axis, and quite across from one side to the other, the section will be an *ellipsis*, as *fig*. 27.

Fig. 30.

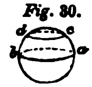


Fig. 31.

Fig. 29.

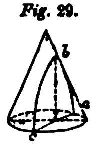


Fig. 28.

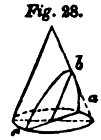
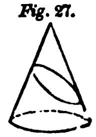


Fig. 27.



A section of a cylinder made in the same manner is also an ellipsis; and this is easily conceived; but it does not appear so readily to most people, that the oblique section of a cone is an ellipsis: they frequently imagine that it will be wider at one end than the other, or what is called an *oval*, which is of the shape of an egg. But that this is a mistake any one may convince himself, by making a cone, and cutting it across obliquely: it will be then seen that the section, in whatever direction it is taken, is a regular ellipsis; and this is the case whether the cone be right or oblique; except only in one case in the oblique cone, which is when the section is taken in a particular direction, which is called *sub-contrary* to its base.

When the section is made parallel to one of the sides of the cone, as *fig*. 28, the curve *a b c*, which bounds the section, is called a *parabola*.

When the section is taken parallel to the axis, as *fig*. 29, the curve is called an *hyperbola*.

The curves which are formed by cutting a cone in different directions are called *conic sections*, and have various properties, which are of great importance in astronomy, gunnery, perspective, and many other sciences.

A *sphere* is a solid terminated by a convex surface, every point of which is at an equal distance from a point within called the *centre*. *Fig*. 30.

It may be conceived to be formed by making a semicircle revolve round its diameter. This may be illustrated by the process of forming a ball of clay by the potter's wheel, a semicircular mould being used for the purpose. The diameter of the semicircle round which it revolves is called the *axis* of the sphere.

The ends of the axis are called *poles*.

Any line passing through the centre of the sphere, and terminated by the circumference, is a *diameter* of the sphere.

Every section of a sphere is a circle; every section taken through the centre of the sphere is called a *great circle*, as *a b*, *fig.* 30; every other is a *lesser circle*, as *c d*.

Any portion of a sphere cut off by a plane is called a *segment;* and, when the plane passes through the centre, it divides the sphere into two equal parts, each of which is called a *hemisphere*.

A *conoid* is a solid produced by the circumvolution of a section of the cone about its axis; and consequently may be either an *elliptical conoid*, a *hyperbolical conoid*, or a *parabolical conoid*. When it is elliptical, it is generally called a *spheroid*. These solids are also called *ellipsoid, hyperboloid*, and *paraboloid*.

A *spheroid* is a solid (*fig.* 31) generated by the rotation of a semi-ellipsis about the transverse or conjugate axis; and the centre of the ellipsis is the centre of the spheroid.

The line about which the ellipsis revolves is called the *axis*. If the spheroid be generated about the conjugate axis of the semi-ellipsis, it is called a *prolate spheroid*.

If the spheroid be generated by the semi-ellipsis by revolving about the transverse axis, it is called an *oblong spheroid*.

Every *section* of a spheroid is an *ellipsis*, except when it is perpendicular to that axis about which it is generated, in which case it is a circle.

All sections of a spheroid parallel to each other are similar figures.

A *frustum* of a solid means a piece cut off from the solid by a plane passed through it, usually parallel to the base of the solid; as the frustum of a cone, a pyramid, &c.

There is a *lower* and an *upper* frustum, according as the piece spoken of does or does not contain the base of the solid.

Ratio is the proportion which one magnitude bears to another of the same kind, with respect to quantity; and is usually marked thus, A : B.

Of these, the first is called the *antecedent*, and the second the *consequent*.

The *measure* or *quantity* of a ratio is conceived by considering what part of the consequent is the antecedent; consequently it is obtained by dividing the consequent by the antecedent.

Three magnitudes or quantities, A, B, C, are said to be *proportional* when the ratio of the first to the second is the same as that of the second to the third; thus, 2, 4, 8, are proportional, because 4 are contained in 8 as many times as 2 in 4.

Four quantities, A, B, C, D, are said to be *proportional* when the ratio of the first, A, to the second, B, is the same as the ratio of the third, C, to the fourth D.

They are usually written A : B : : C : D, or, if expressed in numbers, 2 : 4 : : 8 : 16.

Of *three* proportional quantities, the middle one is said to be a *mean proportional* between the other two; and the last a *third proportional* to the first and second.

Of *four* proportional quantities, the last is said to be a *fourth proportional* to the other three, taken in order.

Ratio of equality is that which equal numbers bear to each other.

Inverse ratio is when the antecedent is made the consequent, and the consequent the antecedent. Thus if 1 : 2 : : 3 : 6; then *inversely*, 2 : 1 : : 6 : 3.

Alternate proportion is when antecedent is compared with antecedent, and consequent with consequent. Thus if 2 : 1 : : 6 : 3; then, by *alternation*, 2 : 6 : : 1 : 3.

Proportion by *composition* is when the antecedent and consequent, taken as one quantity, are compared either with the consequent or with the antecedent. Thus if 2 : 1 : : 6 : 3; then by *composition* $2+1 : 1 : : 6+3 : 3$, and $2+1 : 2 : : 6+3 : 6$.

Divided proportion is when the difference of the antecedent and consequent is compared either with the consequent or with the antecedent; thus if 3 : 1 : : 12 : 4; then by *division* $3-1 : 1 : : 12-4 : 4$, and $3-1 : 3 : : 12-4 : 12$.

Continued proportion is when the first is to the second as the second to the third; as the third to the fourth; as the fourth to the fifth; and so on.

Compound ratio is formed by the multiplication of the several antecedents and the several consequents of ratios together, in the following manner:—

If A be to B as 3 to 5, B to C as 5 to 8, and C to D as 8 to 6; then A will be to D as $\frac{3\times5\times8}{5\times8\times6}=\frac{120}{240}=\frac{1}{2}$; that is, A : D : : 1 : 2.

GERMAN SCHOOL OF PAINTING. With the decline of the Eastern empire, Byzantine art and science were spread over Europe. In Germany as well as in Italy, and particularly on the Rhine, the gloomy, dry style of the Byzantine school prevailed. Many pictures of this early period have been preserved; they are distinguished by a gold ground and ornamented glories made of silver, shaded with brown; their colours are bright, without harmony and without life; their outlines are delicate. In Austria, the Abbot Reginbald, founder of the monastery of Murr, awakened a taste for the arts about 900. He was followed by St. Thiemo, at Saltzburg, and, in particular, by Gisela, the wife of St. Stephen of Hungary. Louis the Debonnaire received costly works of art as presents from the Byzantine emperor. The Silesian and Moravian princes kept up a friendly connection with the Greek emperors. St. Methodius, the missionary to the Sclavonians (863), is mentioned as a distinguished painter; and the first Silesian bishops, who came from Italy, made use of sacred pictures for spreading their religion.

In the churches of St. Elizabeth and St. Barbara, at Breslau, there are some remarkable pictures of this period. The church of St. Bernardine contains the Hedwig's Table, upon which events in the life of St. Hedwig are painted, in 32 compartments. In Bavaria, Theodore II. endeavoured to propagate Christianity by the instrumentality of St. Rupert, whom he called from Worms (696); and here also the introduction of painting followed that of Christianity. The arts were most zealously cultivated in the monasteries of the Benedictines. Alfred and

Ariram, the latter a monk of St.-Emmeran, were the most distinguished Bavarian artists of this time. In Franconia, we find the first traces of art in the time of St. Bruno, who (1042) rebuilt the cathedral at Würtzburg. The Emperor Henry II., and his Queen St. Cunigund, were patrons of the arts.

In the monastery of Heilsbronn, there are several paintings of the time of St. Otho, Bishop of Bamberg, who died 1139. Nuremberg deserves to be mentioned as a place where painting and carving in wood were early carried to a high degree of perfection. The churches of the Virgin Mary and St. Sebaldus contain some very old pictures. In Suabia, the monastery of Hirschau was early celebrated for its treasures of art. Many monasteries and churches contained manuscripts with excellent miniatures. In Augsburg, Culm, and Nördlingen, there were skilful artists at a very early period. From the time of Charlemagne, many branches of art were practised in the cities on the Upper Rhine. Mentz, Treves, and particularly Cologne, were the most distinguished seats of German art at that time. The period from 1153 to 1330 was not less celebrated for German art than for German poetry and language. The oldest German school of painters, which far surpassed the later school of Nuremberg in purity of style, depth of expression, and quiet loveliness, flourished at Cologne during this period. Their pictures are generally on wood, which was first covered with a layer of chalk, and then with linen, upon which was laid another ground of chalk and bole, and, lastly, a gold ground. They preserve their colours with a remarkable freshness. The most celebrated of these works is the altar-piece in the cathedral of Cologne, which some ascribed to William of Cologne, others to Peter Calf.

The collections of Wallraf, Boisserée, and Bettendorf, contain the finest specimens of this period. In Frankfort, the painters on glass were distinguished. The most poetical of the old German masters, Hemmelink, whose works are full of boldness and fire, lived in this period. The builder of the Wartburg, Count Louis II., was a patron of the arts in Hesse and Thuringia. The old church of St. Elizabeth, at Marburg, contains many early monuments. Henry I. protected the arts in Saxony. There were distinguished artists in the abbeys of Corvey, Minden, Hildesheim, and Osnabrück, in Lower Saxony and Westphalia. The number of the monuments of art, from this early time, is incredible. They are found every where in Germany, not only in altar-pieces in the churches and monasteries, but also in elegantly ornamented manuscripts, in chasubles embroidered by the nuns, in needle-work, and altar-cloths.

The Emperor Charles IV. invited many skilful painters to Bohemia, where, as early as 1348, a corporation of painters was formed. In 1450, a distinguished school of painters began to flourish in Breslau, still earlier than that of Nuremberg. Werner of Tegernsee was distinguished for his excellent glass-paintings. In the 15th century, Gleissmyller, Maier, Mächselkircher, Füterer, and Zawnhack were celebrated Bavarian painters; in Nuremberg, Hans Traut, Kulenbach, Hans Bäuerlein, and Michael Wohlgemuth, the latter the teacher of Albert Durer, were eminent.

A second period of German art begins with Albert Durer, who was esteemed by Raphael (from 1471 to 1528). After having studied in the school of Wohlgemuth, he travelled through Germany, the Netherlands, and Italy. Martin Schön may be called the *German Perugino;* his works bear a great resemblance to those of that master. The paintings of Luke Cranach (born 1470, died 1553) have acquired a particular interest from containing the portraits of the most distinguished persons of his time. The Holbein family produced many skilful painters; the most distinguished was Hans Holbein (born 1495, died 1554).

Most of the principal painters of the German school, in the 16th century, were at the same time engravers. Their ideas were truly poetical, but sometimes too allegorical. The execution is finished, but they are deficient in beauty of forms and correctness of outline. Their glowing colours, the expressive attitudes of the figures, the piety which breathes in their countenances, and, particularly, the spirit of their landscapes and back-grounds, must strike every eye. In the 17th and in the first half of the 18th century, art in Germany was in a low state. The German school hardly survived Albert Durer and Holbein. The difficult and artificial only was admired; nature and spirit gave way to laboured ornament. The causes of this decline were the Reformation and the thirty years' war. A melancholy period of imitation followed, in which the taste of Louis XIV. and the exaggerated modern Italian school was the standard. Although Mengs cannot be considered as a restorer of art, at least for Germany, as his plastic principle was entirely opposed to the spirit of painting in general, and, in particular, to the German school, yet he improved the taste of his time by his severe manner. Most of his scholars, however, inclined to a gaudy and often superficial style; but they have produced many pleasing pieces. Among them are Maron, Unterberger, Oser, and Angelica Kaufmann.

William Tischbein, who was born in Hesse, and lived for a long time in Eutin, is among the best artists of our time. His taste is pure, his style noble, his imagination creative and poetical; and his sketches from Homer are celebrated. Many young German artists in Rome have imitated the manner of the old German school, even so far as to copy its faults. More extensive information on German painting may be obtained in Fiorillo's *Geschichte der zeichnenden künste in Deutschland und den Niederlanden,* and in Göthe's *Kunst und Alterthum.*

Ghost, Holy, Order of the; an order of male and female hospitallers. Guy, son of William, Count of Montpelier, founded this order, towards the end of the twelfth century, for the relief of the poor, the infirm, and foundlings. He took the vows himself, and gave a rule to the order. Pope Innocent III. confirmed the order in 1198, and founded an hospital in Rome, on which all the hospitals of the order on the Italian side of the Alps were dependent: all north of the mountains were dependent upon that of Montpelier. This order, which was peculiar for the splendour of its heraldic badges and costume at its first foundation, has now retired into a much more Christian degree of usefulness than that of the knights hospitallers, which was founded for nearly similar purposes in crusading times.

Gilding is the art of applying gold-leaf or gold-dust to surfaces of wood, stone, and metals. The Egyptian monuments present numerous traces of the existence of the art in Egypt. The process was nearly the same with that now used. The artists employed

a sort of paste, like that now used in gilding wood, even for gilding metals; but they were also acquainted with the art of applying the gold directly to the substance to be gilt. The Persians were also skilful in the art of gilding, as appears from the ruins of Persepolis. The Greeks and Romans employed gilding for many purposes. The Greeks used to gild the hoofs and horns of victims. The practice of gilding statues prevailed in the infancy of the art of sculpture, and was never entirely dropped by the ancients. The Romans used to gild sweetmeats; and many articles of furniture and utensils which have come down to us are gilt. There are also specimens of gilt glass and metal.

The gilding, which still remains on some ancient bronze monuments, is remarkable for its brilliancy. This is owing, in part, to the great accuracy of the finish, and in part to the thickness of the leaf, which was much greater than that of the leaf used by the moderns. Besides, we must consider that, in the most common way of gilding brass, with an amalgam of gold and quicksilver, the gold is reduced to a state of much greater subdivision than in the leaf—the only state in which the ancients employed it. The account of Pliny shows that they did not fix the leaf merely by the aid of fire, as is now done in gilding metals, but that they first covered the substance, which was then evaporated by heat, in a manner somewhat similar to the modern practice of gilding with amalgam. The ancients carried the practice of gilding to a greater extent than the moderns; they gilded almost all their statues of bronze, wood, or plaster, and frequently those of marble, the ceilings of rooms, and even marble columns, eatables, and victims. The *bracteatores*, or *inauratores*, were in high esteem among them, and enjoyed an exemption from taxes.

In architectural ornaments, gilding may please the eye either from its appearance of richness, or merely from its agreeable colour. The most remarkable examples of gilding, employed with taste and effect, in architecture, are the ceiling of St. Peter's, and that of Santa Maria Maggiore. But artists often fall into the error of mistaking richness of appearance for beauty. The art of gilding, at the present day, is performed either upon metals, or upon wood, leather, parchment, or paper; and there are three distinct methods in general practice: namely, *wash*, or *water-gilding*, in which the gold is spread, whilst reduced to a fluid state, by solution in mercury; *leaf-gilding*, either burnished or in oil, performed by cementing thin leaves of gold upon the work, either by size or by oil; and *japanner's gilding*, in which gold-dust or powder is used instead of leaves.

Gilding on copper is performed with an amalgam of gold and mercury. The surface of the copper, being freed from oxide, is covered with the amalgam, and afterwards exposed to heat till the mercury is driven off, leaving a thin coat of gold. It is also performed by dipping a linen rag in a saturated solution of gold, and burning it to tinder. The black powder thus obtained is rubbed on the metal to be gilded, with a cork dipped in salt-water, till the gilding appears. Iron or steel is gilded by applying gold-leaf to the metal, after the surface has been well cleaned, and heated until it has acquired the blue colour, which at a certain temperature it assumes. The surface is previously burnished, and the process is repeated, when the gilding is required to be more durable. It is also performed by diluting the solution of gold in nitro-muriatic acid, with alcohol, and applying it to the clean surface. This last process has been improved by Mr. Stoddart. A saturated solution of gold in nitro-muriatic acid, being mixed with three times its weight of sulphuric ether, dissolves the muriate of gold, and the solution is separated from the acid beneath. To gild the steel, it is merely necessary to dip it, the surface being previously well polished and cleaned, in the ethereal solution, for an instant, and, on withdrawing it, to wash it instantly by agitation in water. By this method, steel instruments are very commonly gilt.

GIMBALS; the brass rings by which a sea compass is suspended in its box, so as to counteract the effect of the ship's motion, and keep the card horizontal.

GIN. See GENEVA.

GINSENG. The root of this plant has been celebrated for a long time among the Chinese, entering into the composition of almost every medicine used by the higher classes; and, indeed, so highly is it prized as to have received the appellations of "pure spirit of the earth" and "plant that gives immortality." Volumes have been written on its virtues, and recourse had to it in every difficulty. The plant, which is the *panax quinquefolium* of botanists, is herbaceous, about a foot high, upright, and very simple, furnished above with three petiolate leaves, disposed verticillately: these leaves are composed of five unequal leaflets, which are oval, lanceolate, acute, and dentate on the margin: from the centre of the three leaves arises a peduncle, terminated by a small umbel of greenish inconspicuous flowers, which are succeeded by rounded and slightly compressed scarlet berries. It is said to be a native of Tartary, growing wild in a mountainous and wooded region between lat. 39° and 47°, where it is collected with many precautions by the Chinese and Tartars, at the commencement of spring and in the latter part of autumn, and is so rare as to bring three times its weight in silver. An early traveller relates, that the Emperor of China employed, in one year, 10,000 Tartars in procuring this root. From China it is imported into Japan, where it was obtained by the Dutch, who first brought it to Europe. Notwithstanding the extravagant price and high reputation of ginseng in China, it appears to be really a plant of very little efficacy; the taste is sweet and mucilaginous, accompanied with some bitterness, and also slightly aromatic.

GLACIERS. The summits and sides of mountains, above the limit of perpetual snow (see SNOW), are covered with a crust, which is harder than common snow, yet not like common ice. More ice is formed on the sides of mountains than on their summits; but this does not constitute the *glaciers*, properly so called. The glaciers are vast fields of ice, extending from the declivities of the mountains down into the valleys, below the snow-line. They are often horizontal, generally, however, a little inclined.

The ice of the glaciers is entirely different from that of sea or river water. It is not formed in layers, but consists of little grains of congealed snow; and hence, though perfectly clear and often smooth on the surface, it is not transparent. Its fracture is not radiated, like that of sea-ice, but granular. In the numerous fissures, however, the ice near the surface has a greenish, near the bottom a blue cast. Along the edges of the glaciers are the *moraines*, as they are called in Savoy (in Iceland, jökelsgiärde). They consist of an accumulation of earth, which is

often several fathoms high, and, in summer, present the appearance of bottomless morasses, producing no vegetation. It is probable that these *moraines* are produced by the melting of the lower part of the glacier, which always takes place in summer, without which the annual accumulation of snow, in winter, would form an endless crust. The great ice-fields are also continually extending farther down into the valleys, where, in summer, they are at last partially melted by the warmer temperature.

In Lapland, where the sun has less power, glaciers slide down in the region of the Sulitelma, which render the air so cool, that the line of perpetual snow extends as low as 3000 feet above the level of the sea. The descent of the glaciers, which is assisted in summer by the avalanches, is greater or less, according to the inclination of the glacier. This is shown by the changes in the position of large masses of rock around the glaciers. They are evidently pushed along by the ice, and, near the Grindelberg, in Switzerland, it has been found, by examination, that stones have been pushed forward 25 feet in one year. Stones of considerable bulk are also seen in the *moraines* of an entirely different formation from those of the valley, and must therefore have been pushed down from the higher regions in the course of time. As glaciers, in some positions, and in hot summers, decrease, they often also increase for a number of years, so as to render a valley uninhabitable. Their increase is caused partly by alternate thawing and freezing; their decrease, by the mountain rivers, which often flow under them, and thus form an arch of ice over the torrent. Streams are seen at the bottom of the deepest fissures, which, in the Helvetic Alps, are called *dust* or *powder avalanches*, because they consist of newly fallen snow, which is carried by the wind into the depths. There are also, particularly in the Norwegian Alps, *dirt avalanches*, so called, which carry along stones and earth with them, and increase the *moraines* of the glaciers.

In the Tyrol, Switzerland, Piedmont, and Savoy, the glaciers are so numerous that they have been calculated to form altogether a superficial extent of 1484 square miles. There are some glaciers, in Savoy, more than 14 miles long, 2½ miles wide, and from 60 to 600 feet thick. One of the most famous glaciers is the *mere de glace* (sea of ice) in the valley of Chamouni, about 5700 feet above the level of the sea. In France, near Beaume, and in the Carpathian mountains, near Dselitz, are subterraneous glaciers, which never melt, because the sun cannot act upon them. From this account it is evident that there can be no glaciers in the Andes, because the temperature continues the same the whole year between the tropics. The noise which is produced by the opening of fissures in the glaciers is immense, and resembles thunder among the mountains. These fissures are often immediately covered with snow, and are therefore very dangerous to travellers.

Glacis, in *fortification*, is the sloping covering of the outer breastwork along the covered-way, which descends to the level ground, and covers the ditch upon the outside. It must be so placed, that the guns of the fort will rake it at every point.

Glass. This valuable manufacture commenced early. Pliny informs us that Sidon was the first city distinguished for its glass-works, and that the manufacture of glass was not introduced into Rome until the reign of Tiberius. He farther states, that, in the reign of Nero, the art of making vases and cups of a white, transparent glass, was invented. De Pauw is of opinion that the Egyptians carried the art to the highest perfection; and that the glass-works at Diospolis, capital of the Thebaïd, formed the first regular manufactory of this material. The Egyptians, according to the same author, performed the most difficult operations in glass-cutting, and manufactured cups of glass of an astonishing purity, of which kind were those called *alassontes*, supposed to be ornamented with figures in changeable colours. Winckelmann says that the ancients, in general, made much greater use of glass than the moderns. Besides the ordinary utensils, of which a great quantity have been found in Herculaneum, we find many funeral urns constructed of it. Some of the fragments of cups examined by Winckelmann appeared to have been cut; others of raised ornaments having the appearance of being soldered to the surface of the vessels, and bearing marks of the lapidary's wheel on their *facettes*. The ancients also used glass to ornament their rooms; for this purpose, they employed it of various colours, and composed a sort of mosaic of it.

Some blocks of glass, used for paving rooms, have been found of the thickness of a common-sized brick. Winckelmann cites some specimens of mosaic of remarkable beauty and delicacy. One of them represented a bird on a dark and coloured ground. The colours of the bird were very brilliant and various, and the whole effect very soft. The artist had made use of opaque, or transparent glass, according to the exigencies of the case. What was not the least remarkable was, that the reverse offered precisely the same figure, without the slightest difference in the details. A little glass ring, which was in the possession of Sir W. Hamilton, showed the method in which this was performed. The exterior of the ring was blue, and the interior represented a species of rose, of different colours, extending the whole circuit of the ring. As melted glass may be drawn out into an amazingly fine wire, this operation may be performed on pieces of glass, compounded of different colours and melted, the colours preserving the respective layers when wire-drawn. Caylus thinks this was the manner in which these works of art were made. The most valuable remains of the ancients, in glass, are the impressions and casts of sculptured gems, both in sunk and raised work, and the larger works in relief, of which one whole vase has come down to us. The glass casts of intaglios often imitate the veins of different colours in the original. These pastes have preserved the impressions of many beautiful gems which are lost. Of the larger works in relief we have only some fragments: they served as ornaments to the walls of palaces. The most considerable work of this kind is the cameo described by Buonarotti, and preserved in the Vatican: it is an oblong tablet of glass, about 8 inches by 6, representing Bacchus and Ariadne, with two satyrs. But the most beautiful specimens of this art are the vases adorned with figures in relief: they were sometimes transparent, sometimes of different colours on a dark ground, and so delicately executed, that they were hardly to be distinguished from the vases of sardonyx. The Portland Vase is the only one of this sort preserved entire. It was formerly called the *Barberini Vase*, as it belonged to the Barberini palace at Rome. It is about a foot high, and was at first

described as a sardonyx. It is now preserved in the British Museum under the name of the Portland Vase.

Glass is made by melting silicious earth or sand, alkaline substances, and a metallic oxide, at a white heat. The name is an old German word, and is connected with *gleissen* (to shine), and with the English word *glisten*, and even with *glacies* (ice) and *glanz* (splendour). The manufacture of glass is now brought to a high degree of perfection, especially in this country.

The English glass-houses are commonly large conical buildings, from 60 to 100 feet high, and from 50 to 80 feet in diameter. A representation of one is given in our *Plate* of GLASS MANUFACTURE. The furnace is in the middle, over a large vault, which is connected with it by means of an opening. This opening is covered with an iron grate, upon which the fire is made, and it is kept up by the draught of air from the vault. The most important part, however, of the apparatus of the glass-house, is the crucible. These instruments are made from a particular kind of clay, which is found at Stourbridge. This is first pounded fine, then sifted, moistened, and worked into a thick dough. Sometimes old crucibles are used, which are broken into powder, and then mixed with a red clay. Some pots, for bottle and flint glass, are made 40 inches deep and wide. They are from two to four inches in thickness. They remain several days at a white heat, before they are placed in the furnace for use. The basis of glass is *silica*.

When flints or quartz are used, they are first reduced to powder by being heated red hot, and then plunged into cold water. This causes them to whiten and fall to pieces, after which they are ground and sifted. The second ingredient is an alkaline substance, potash or soda. The alkali used is more or less pure, according to the fineness of the glass to be made. Lime is often employed in small quantities; also borax. Of the metallic oxides added in different cases, the deutoxide of lead is the most common. It renders flint-glass more fusible, heavy, and tough, and more easy to be ground and cut, and increases its brilliancy and refractive power. A small quantity of black oxide of manganese renders the glass more transparent; too much gives a purple tinge, which, however, may be destroyed by a little charcoal or wood. Arsenious acid (white arsenic), in small quantities, promotes the clearness of glass; too much of it gives the glass a milky whiteness. Its use in drinking-vessels is not free from danger, if the glass contains so much alkali that any part is soluble in acids. The following are the processes employed in making glass:—

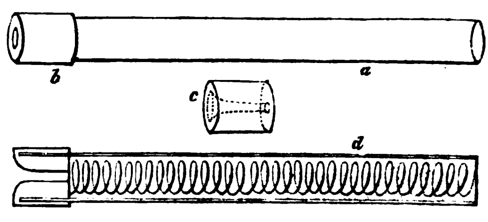
Fritting. The various materials are carefully washed, and, after the extraction of all the impurities, are conveyed to the furnace in pots made of pipe-clay. The produce of this process is called the *frit*, which is again melted in large pots or crucibles, till the whole mass becomes beautifully clear, and the dross rises to the top.

Blowing is the next process, which, in round glass, as phials, drinking-glasses, &c., is thus performed:— The workmen dip the end of long iron pipes, red hot, into the liquid glass, then roll it on a polished iron plate to give it an external even surface; they next blow down the iron pipe, till it enlarges the metal like a bladder, and, if necessary, roll it again on the iron plate, and proceed to form it into a globular form, or any other one required. The glass is then transferred from the blowing-pipe, by dipping the end of another iron rod into the liquid glass, which adheres to the heated rod, and with which the workman sticks it to the bottom of the vessel; then, with a pair of pincers, wetted with water, he touches the neck, which immediately cracks, and, on being slightly struck, separates at the end of the blowing-pipe, and becomes attached to the iron rod. The vessel is next carried up to the mouth of the furnace, to be heated and softened, that the operator may finish it. If the vessel require a handle, the operator forms it separately, and unites it while melting hot, forming it with pincers to the requisite shape and pattern.

We have now to notice a most important improvement in the process of blowing glass. It is effected by what is termed a glass-blower's artificial lungs.

This simple little instrument is the invention of a French workman; it enables the glass-blower to give a blast of any power that he wishes through the pipe or cane, and thereby blow much larger objects than by the lungs, and that with nearly the sharpness of cut glass. This discovery has reduced the price of crystal upwards of 30 per cent., as all melon ribbed glasses, decanters, &c., are now blown as perfectly as if they were cut. The Institute of France decreed M. Montyon's prize of 5000 francs, "for the best invention for preserving the health of workmen," to the inventor.

Sir John Byerley brought one of these instruments from Paris, and exhibited it at the Royal Institution in 1832. The instrument is composed of a tin tube about 15 inches long and 1½ inch in diameter: in this is a spiral spring, in the cup of which is an air-tight piston, about 2 inches long, perforated in the centre. The diameter of the orifice is the same, or rather less, than that of the blowing-cane, to the other end of which the glass is attached. The vitreous matter being placed in the mould in the usual way, instead of blowing through the tube or cane, as formerly, the instrument is applied to the end of it, and pressed smartly down—the spring is compressed, and the air in the instrument forced into the cane, and thence into the object.



a is the instrument ready for work; *b*, the tin cap, which fixes on to the tube with a latch, to keep down the piston, which the spring would otherwise force out. The cap is perforated with a hole rather larger than the diameter of the cane.

The lower figure is a section of the instrument, in which is seen the piston and the spiral spring, *d*. The top of the piston is hollowed off towards the middle, that the cane may be sure to be applied to the orifice. This upper part of the piston is covered with leather, which is oiled, so that the cane pressing upon it no air can escape laterally. A separate view of the mouth is seen at *c*. The instrument is made of tin; and the price in France is half a crown.

GLASS MANUFACTURE.

Fig. 2.

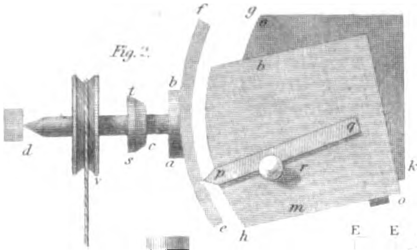


Fig. 3.

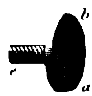


Fig. 4.

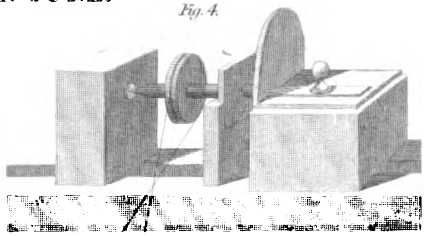


Fig. 1.

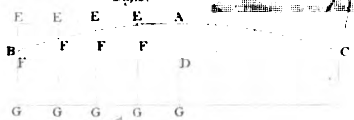


Fig. 6.

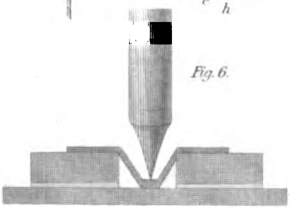


Fig. 5.

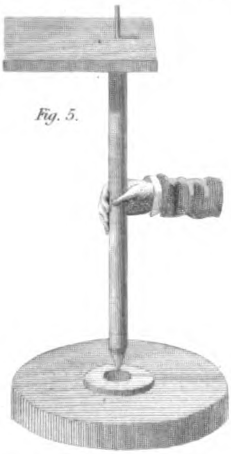
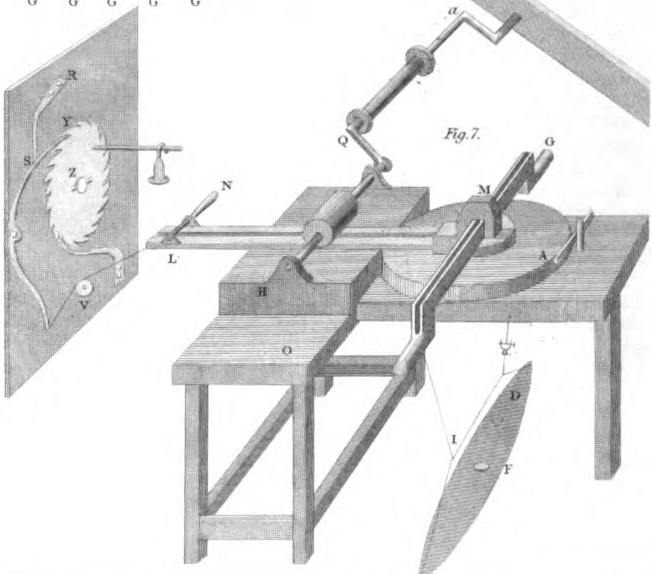
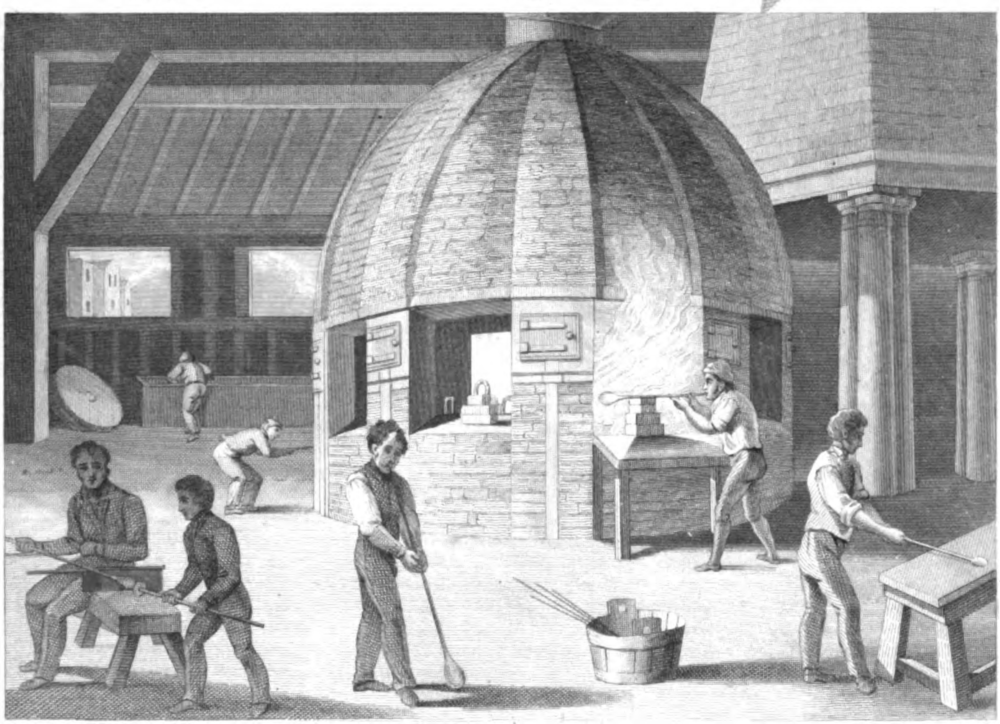


Fig. 7.





INTERIOR OF A GLASS HOUSE.

Drawn by Charles Blunt. *London Published by William Orr Paternoster Row* *Engraved by J. Dower*

Annealing is the removing of the glass, after it has been blown or cast, into a furnace whose heat is not sufficiently intense to melt it, and gradually withdrawing the article from the hottest to a cooler part of the annealing chamber, till it is cold enough to be taken out for use. If cooled too suddenly, it is extremely brittle.

Colouring. The different coloured glasses owe their tints to the different metallic oxides mixed with the materials while in a state of fusion. In this manner are made those elegant *pastes*, which so faithfully imitate, and not unfrequently excel, in brilliancy, their originals, the gems of antiquity. The glass, however, for this purpose, is prepared in a peculiar manner, and requires great nicety. It combines purity and durability. *Opaque* glass is made by the addition of the oxide of tin, and produces that beautiful imitation of enamel which is so much admired. Dials for watches and clocks are thus made. The principal sorts of glass may be now described:—

Crown-glass is the best sort of window glass, and differs from the flint-glass in containing no lead, nor any metallic oxide, except manganese, and sometimes oxide of cobalt in minute portions, not as flux, but for correcting the natural colour. This glass is much harder and harsher to the touch than the flint-glass; but, when well made, it is a very beautiful article. It is compounded of sand, alkali, either potash or soda, the vegetable ashes that contain the alkali, and generally a small portion of lime. A small dose of arsenic is often added, to facilitate the fusion. Zaffre, or the oxide of cobalt, with ground flint, is often used to correct the dingy yellow of the inferior sort of crown-glass; and, by adding the blue, natural to glass coloured with this oxide, to convert the whole into a soft light green. One ounce of zaffre is sufficient for 1000 lbs. But when the sand, alkali, and lime are very fine, and no other ingredients are used, no zaffre, or corrective of bad colour, is required. A very fine glass of this kind may be made by 200 parts of pretty good soda, 300 of fine sand, 33 of lime, and from 250 to 300 of the ground fragments of glass. We had formerly in London two kinds of crown glass, distinguished by the places where they were wrought; viz. 1. Ratcliff crown-glass, which is the best and clearest, and was first made at the Bear Garden, on the Bank-side, Southwark, but since at Ratcliff: of this there are twenty-four tables to the case, the tables being of a circular form, about three feet six inches in diameter. 2. Lambeth crown-glass, which is of a darker colour than the former, and more inclining to green.

The following composition has been recommended for the best window or crown-glass: white sand, 60lbs.; purified pearl-ashes, 30 lbs.; salt-petre, 15lbs.; borax, 1lb.; and arsenic, half a pound. If the glass should prove yellow, manganese must be added. A cheaper composition for window-glass consists of 60lbs. of white sand, 25lbs. of unpurified pearl-ashes, 10lbs. of common salt, 5lbs. of nitre, 2lbs. of arsenic, and 1½ oz. of manganese. The common or green window-glass is composed of 60lbs. of white sand, 30lbs. of unpurified pearl-ashes, 10lbs. of common salt, 2lbs. of arsenic, and 2 oz. of manganese. But a cheaper composition for this purpose consists of 120lbs. of the cheapest white sand, 30lbs. of unpurified pearl-ashes, 60lbs. of wood ashes, well burnt and prepared, 20lbs. of common salt, and 5lbs. of arsenic.

The manufacture of the common window-glass, though made by blowing, is conducted differently from that of the flint-glass articles, as it is the object to produce a large, flat, and very thin plate of glass, which is afterwards cut by the glazier's diamond into the requisite shape. Without minutely detailing the several gradations of the process, it may be here mentioned that the workman takes a very large mass of melted glass on his hollow iron rod, and, by rolling it on an iron plate and swinging it backwards and forwards, causes it to lengthen by its own weight into a cylinder, which is made hollow and brought to the required thinness by blowing with a fan of breath, which persons accustomed to the business know how to command. The hollow cylinder is then opened by holding it to the fire, which, by expanding the air confined within it (the hole of the iron rod being stopped), bursts it at the weakest part, and, when still soft, it is opened out into a flat plate by the centrifugal force, and finished by annealing, as usual.

Newcastle glass is of an ash colour, frequently speckled, streaked, and blemished. It is made from white sand, unpurified barilla, common salt, arsenic, and manganese.

The *bottle* or *green glass*, usually made of common sand, lime, and some clay, fused with an impure alkali, is very hard, and resists the corrosive action of all liquids much better than flint-glass: the green colour is owing to the iron: and it is well adapted for chemical vessels.

Flint-glass, the most fusible of any, is used for bottles, utensils intended to be cut and polished, and for various ornamental purposes. The best kind is composed of white silicious sand, pearl-ash, red oxide of lead, nitrate of potash, and the black oxide of manganese. It fuses at a lower temperature than crown-glass, has a beautiful transparency, a great refractive power, and a comparative softness, which enables it to be cut and polished with ease. On this account it is much used for glass vessels of every description, and especially those which are intended to be ornamented by cutting. It is also employed for lenses and other optical glasses. Flint-glass is worked by blowing, moulding, pressing, and grinding. Articles of complex form, such as lamps and wine-glasses, are formed in pieces, which are afterwards joined by simple contact, while the glass is hot. It appears that the red lead used in the manufacture of flint-glass gives up a part of its oxygen, and passes to the state of a protoxide.

Plate-glass, so called from its being cast in plates or large sheets, is the most valuable, and is used for mirrors and the windows of carriages. It is composed of white sand, cleansed with purified pearl-ashes and borax. But, should the metal appear yellow, it is restored to its pellucid transparency by the addition (in equal proportions) of a small quantity of manganese and arsenic. It is cast on a large horizontal table, and all excrescences are pressed out by passing a large roller over the metal. To polish the glass, it is laid on a large horizontal table of freestone, perfectly smooth; and then a smaller piece of glass, fastened to a plank of wood, is passed over the other till it has received its due degree of polish. But, to facilitate this process, water and sand are used, as in the polishing of marble; and, lastly, Tripoli, smalt, emery, and putty, to give it lustre.

Grinding and *polishing* give plate-glass a fine lustre. The grinder takes it rough out of the hands of the caster, and, laying it upon a stone table, to which it is fixed with stucco, he lays another rough glass, half the size of the former, upon it. To the smaller glass a plank is fastened, by means of stucco, and to the whole a wheel, made of hard, light wood, about six inches in diameter, by the pulling of which from side to side, and from end to end, of the glass, a constant attrition is kept up; and, by allowing water and fine sand to pass between the plates, the whole is very finely polished; but, to give the finishing polish, powder of smalt is used. As the upper glass grows smoother, it is taken away, and a rougher one substituted in its stead; and so on till the work is done. Except in the very largest plates, the workmen polish their glass by means of a plank, having four wooden handles to move it; and to this plank a plate of glass is cemented, as above.

Achromatic flint-glass. The excise laws of England have prevented our artists from attempting to melt glass on a proper scale for making lenses for achromatic telescopes; but in France, where no such restrictions exist, numerous attempts have been made to perfect the manufacture of flint-glass for optical purposes; and M. Guinaud's labours have been finally crowned with complete success. The almost total impossibility of procuring flint-glass exempt from striæ, suggested to this artist the construction of a furnace capable of melting two cwt. of glass in one mass, which he sawed vertically, and polished one of the sections, in order to observe what had taken place during fusion. He discovered his metal to be vitiated by striæ, specks or grains, with cometic tails; and, from time to time, as he obtained blocks, including portions of good glass, his practice was to separate them by sawing the blocks into horizontal sections, or perpendicular to their axes. A fortunate accident conducted him to a better process. While his men were one day carrying a block of this glass, on a hand-barrow, to a saw mill which he had erected at the fall of the Doubs, the mass slipped from its bearers, and, rolling to the bottom of a steep and rocky declivity, was broken to pieces.

M. Guinaud, having selected those fragments which appeared perfectly homogeneous, softened them, in circular moulds, in such a manner that, on cooling, he obtained disks that were afterwards fit for working. To this method he adhered, and contrived a way for clearing his glass while cooling, so that the fractures should follow the most faulty parts. When flaws occur in the large masses, they are removed by cleaving the pieces with wedges; then melting them again in moulds, which give them the form of disks; taking care to allow a little of the glass to project beyond one of the points of the edge, so that the optician may be enabled to use that portion of glass in making a prism, which shall give the measure of the index of refraction, and thus obviate the necessity of cutting the lens. The Astronomical Society of London have tried disks of M. Guinaud's flint achromatic glass, which seems entirely homogeneous, and exempt from fault. This material grinds and polishes much easier than the English flint-glass. (For Professor Faraday's improvements in the manufacture of glass for lenses, see LENS.)

Various ornamental forms are given to the surface of glass vessels by metallic moulds. The mould is usually of copper, with the figure cut on its inside, and opens with hinges to permit the glass to be taken out. The mould is filled by a workman, who blows fluid glass into its top. The chilling of the glass, when it comes in contact with the mould, impairs its ductility, and prevents the impression of the figure from being sharp. Some moulds, however, are made in parts, which can be suddenly brought together on the inside and outside of the glass vessel, and produce specimens nearly equal to cut-glass.

Cut-glass, so called, is produced by grinding the surface with small wheels of stone, metal, or wood. The glass is held to the surface of the wheels. The first cutting is with wheels of stone; then with iron, covered with sharp sand or emery; and, finally, with brush wheels, covered with putty. A small stream of water is kept continually running on the glass, to prevent the friction from exciting too much heat.

The physical properties of glass are of the highest importance. One of these is that of preserving its transparency in a considerable heat, and remaining with very little extension. Its expansibility is less affected by heat and cold than that of most other solid substances which have been accurately examined. It may be cut by the diamond, and also by a hot iron, although the latter manner is rather unsafe. Should this plan be resorted to, a pointed iron wire must be employed; and, as soon as the line of division is well indicated, the glass should be moistened with cold water, which causes it to separate.

Drops of Glass, which have been let fall, while melted, into water, commonly called *Prince Rupert's drops*, assume the form of an oval body, terminating in a long slender stem. They are also called *glass tears*. The large part may be struck with a hammer, or filed, without breaking; but, if the stem is broken, the whole flies to pieces.

Glass Galls; a substance which floats upon melted glass, like scum or froth, called by the French *siel*, or *suif de verre*. It is principally alkaline, and attracts moisture from the air, so as even to become fluid. It is chiefly used for soldering silver, stands a strong heat, is a good flux for substances difficult to fuse, and keeps them long in a state of fusion. Potters also use it for glazing.

Glass Threads. The great ductility of glass enables it to be drawn into the finest threads. A piece of glass is held over the flame of a lamp, till it becomes soft: a hook is then fixed into it, and it is drawn out into a thread. The hook being fixed in the circumference of a small revolving cylinder, the glass thread is wound round the cylinder. Réaumur succeeded in obtaining these threads as fine as a spider's web.

Glass Windows. The mode of preparing glass was known long before it was thought of making windows of it. Houses in Oriental countries had commonly no windows in the front, and towards the court-yard they were provided with curtains or a moveable trellis-work; and in winter they were covered with oiled paper. The Chinese made use, for windows, of a very fine cloth, covered with a shining varnish; and, afterwards, of split oyster shells. They had also the art of working out the horns of animals into large and thin plates, with which they covered their windows. In Rome, the *lapis specularis* supplied the place of glass, and, from the description, seems to have been nothing but thin leaves of talc. Rich people had the windows or openings in their baths filled with thin plates of agate or marble. It was hastily concluded

that glass was used for windows in the time of Titus, because fragments of glass plates have been found at Pompeii, which town was destroyed in his reign; but the first certain information of this mode of using glass is to be found in Gregory of Tours, who speaks of the churches having windows of coloured glass in the fourth century after Christ, that is, in the reign of Constantine the Great, when they were to be seen in the church of St. Paolo Fuori le Mura. In France, talc or isinglass, white horn, paper soaked in oil, and thin shaved leather, were used instead of glass. The oldest glass windows at present existing are of the twelfth century, and are in the church of St. Denis: they appear to have been preserved as part of the old church, which was erected before the year 1140, by the Abbot Suger, a favourite of Louis le Gros. Suger had sapphires pounded up and mixed with the glass, to give it a blue colour. Æneas Sylvius accounted it one of the most striking instances of splendour which he met in Vienna, in 1458, that most of the houses had glass windows. Felibien says that, in his time (1600), round glass disks were set in the windows in Italy. In France, on the other hand, there were glass windows in all the churches, in the sixteenth century, although there were but few in dwelling-houses.

Glass, painting on. This art was, perhaps, known to the ancients, as Morisoli attempts to prove from passages in Seneca and Vopiscus Firmius; and some persons consider the fact established by a relic of art, described in Buonarotti's *Observations upon some Fragments of Ancient Vases of Glass*, &c.—Painted glass was much used, formerly, to ornament windows in churches and other public buildings, and, in unison with the whole style of Gothic churches, threw a gloomy shade over the whole interior. Speth distinguishes between the painting on glass, or glass-enamel, and two inferior kinds of the art; one painting upon, or rather behind, glass which is not perfectly transparent; and the other, which requires transparent glass, but makes use only of coloured varnishes, or transparent colours, which do not resist moisture. Painting upon glass, properly so called, had its origin in the 3d century, about the time of the first specimens of mosaic. The more extensive knowledge, as well as use, of coloured glass, was communicated from France to England; and from thence, in the 8th century, by means of missionaries, to Germany and Flanders, and, in the 9th century, was carried to the north. Although the Italians used painted glass for mosaic work, yet they appear not to have applied it to church windows before the 8th century. We find undoubted traces of it in Bavaria towards the end of the 10th century. There was a glass-house at Tegernsee, near Münich. In the 11th century, the imitation of the best pieces of mosaic work in paintings upon glass was commenced. This art derived great advantages, at the end of the 14th century, from the important invention of enamel painting, or the art of fixing the metallic colours in glass. The art flourished most during the 15th and 16th centuries. France, England, and the Netherlands, boasted first-rate artists in this department, as Henriet, Monier of Blois, and Ab. von Diepenbecke. In Germany, Durer gained celebrity in the same art. It declined in the 17th century, and, yielding to the force of fashion, it ceased to be heard of in the 18th. It was then carried on in England chiefly by foreign artists. In the reign of James I., a school was founded by a Netherlander, Bernh. de Linge, who may be regarded as the father of modern painting upon glass. The school has continued to this day. There were some artists, in the 17th and 18th centuries, who gained reputation by their paintings upon glass, as Eginton of Birmingham, Wolfgang Baumgärtner of Kufstein, in the Tyrol (who died 1761), and their contemporary Jouffroy, who painted, in a chapel in London, the Resurrection of the Saviour. The knowledge acquired by experience was not lost, but the practice of the art was very limited. The great window of New College, Oxford, affords a fine specimen of British art.

In Germany, painting upon glass was revived in the 19th century. M. S. Frank, of Nuremberg, first attempted to restore it to its proper rank. He was employed as a painter on glass at the royal porcelain manufactory, at Münich. The royal cabinet of medals possesses a Birth of Christ by him, and the chapel a Supper, which was made in imitation of Durer's small Passion. The works in painted glass produced at Berlin and Vienna are not comparable with his. In the castle of Marienburg, in Prussia, recently rebuilt, are some paintings upon glass, which may even be compared to the ancient specimens.

GLAUBER SALTS. See SULPHATE OF SODA.

GLAZING. To prevent the penetration of fluids, it is necessary that earthen vessels should be glazed, or covered with a vitreous coating. The materials of common glass would afford the most perfect glazing to earthenware, were it not that the ratio of its expansion and contraction is not the same with that of the clay; so that a glazing of this sort is liable to cracks and fissures, when exposed to changes of temperature. A mixture of equal parts of oxide of lead and ground flints is found to be a durable glaze for the common cream-coloured ware, and is generally used for that purpose. These materials are first ground to an extremely fine powder, and mixed with water to form a thin liquid. The ware is dipped into this fluid and drawn out. The moisture is soon absorbed by the clay, leaving the glazing particles upon the surface. These are afterwards melted by the heat of the kiln, and constitute a uniform and durable vitreous coating. The English and French manufacturers find it necessary to harden their vessels by heat, or bring them to the state of biscuit, before they are glazed; but the composition used by the Chinese resists water, after it has been once dried in the air, so as to bear dipping in the glazing liquid without injury. This gives them a great advantage in the economy of fuel.

GLEE, in *music;* a vocal composition in three or more parts, generally consisting of more than one movement, the subject of which may be either gay, tender, or grave, bacchanalian, amatory, or pathetic.

GLOBE, or ARTIFICIAL GLOBE, is a term more particularly used to denote a globe of metal, plaster, paper, pasteboard, &c., on the surface of which is drawn a map, or representation of either the heavens or the earth, with the several circles which are conceived upon them; the former being called the *terrestrial globe*, and the latter the *celestial globe*.

The *celestial globe* is an inverted representation of the heavens, on which the stars are marked according to their several situations. The diurnal motion of this globe is from east to west, to represent the apparent

diurnal motion of the sun and stars. The eye is supposed to be placed in the centre of this globe, but, in fact, it is beyond the stars.

The *terrestrial globe* is an artificial representation of the earth, exhibiting its great divisions. The diurnal motion of this globe is from west to east.—The axis of the earth is an imaginary line passing through its centre; and the wire on which the artificial globe turns represents this line. The poles of the earth are the extremities of this axis; that on the north is called the *arctic*, that on the south the *antarctic* pole. The celestial poles are imaginary points in the heavens, exactly above the terrestrial poles. The brazen meridian is the circle in which the artificial globe turns, divided into 360 degrees. Every circle is supposed to be divided into 360 equal parts, called *degrees*, each degree into 60 equal parts, called *minutes*, each minute into 60 equal parts, called *seconds*, &c.; a degree is therefore only a relative idea, and not an absolute quantity, except when applied to a great circle of the earth, as to the equator or to a meridian, in which cases it is 60 geographical miles, or 69½ English miles.

A degree of a great circle in the heavens is a space nearly equal to twice the apparent diameter of the sun; or to twice that of the moon, when considerably elevated above the horizon. Degrees are marked with a small cipher, minutes with one dash, seconds with two, thirds with three, &c.; thus, $25^\circ\ 14'\ 22''\ 35'''$ are 25 degrees, 14 minutes, 22 seconds, 35 thirds. In the upper semicircle of the brass meridian, these degrees are numbered 10, 20, &c., to 90, from the equator towards the poles, and are used for finding the latitudes of places. On the lower semicircle of the brass meridian, they are numbered 10, 20, &c., to 90, from the poles towards the equator, and are used in the elevation of the poles.

Great circles, as the equator, ecliptic, and the colures, divide the globe into two equal parts. Small circles, as the tropics, polar circles, parallels of latitude, &c., divide the globe into two unequal parts. Meridians, or lines of longitude, are semicircles, extending from the north to the south pole, and cutting the equator at right angles. Every place upon the globe is supposed to have a meridian passing through it, though there be only 24 drawn upon the terrestrial globe; the deficiency is supplied by the brass meridian. When the sun comes to the meridian of any place (not within the polar circles), it is noon or mid-day at that place. The first meridian is that from which geographers begin to reckon the longitudes of places. In English maps and globes, the first meridian is a semicircle, supposed to pass through London, or the Royal Observatory at Greenwich. The equator, a great circle of the earth, equidistant from the poles, divides the globe into two hemispheres, northern and southern. The latitudes of places are reckoned from the equator northward and southward, and the longitudes are reckoned upon it eastward and westward. The equator, when referred to the heavens, is called the *equinoctial*, because, when the sun appears in it, the days and nights are equal all over the world, viz. 12 hours each. The declination of the sun, stars, and planets, is counted from the equinoctial northward and southward; and their right ascensions are reckoned upon it eastward round the celestial globe, from 0 to 360 degrees.

The ecliptic is a great circle in which the sun makes his apparent annual progress among the fixed stars. It is the real path of the earth round the sun. The points at which the ecliptic intersects the equator, at an angle of $23^\circ\ 28'$, are called the *equinoctial points:* the ecliptic is situated in the middle of the zodiac. The apparent path of the sun is either in the equinoctial, or in lines nearly parallel to it, and his apparent annual path may be traced in the heavens, by observing what particular constellation in the zodiac is on the meridian at midnight; the opposite constellation will show, very nearly, the sun's place at noon on the same day. The zodiac on the celestial globe is a space which extends about 8° on either side of the ecliptic. Within this belt the motions of the planets are performed.

The ecliptic and zodiac are divided into 12 equal parts, called *signs*, each containing 30°; and the sun makes his apparent annual progress through the ecliptic, at the rate of nearly a degree in a day. The names of the signs, and the days on which the sun enters them, are given in the article ECLIPTIC. The colures, two great circles passing, one through the points Aries and Libra and the poles of the world, the other through Cancer and Capricorn and the poles of the world, have their uses in mechanical geography. That passing through Aries and Libra is called the *equinoctial* colure; that passing through Cancer and Capricorn, the *solstitial* colure. The tropics are two smaller circles, each $23^\circ\ 28'$ from the equator, with which they are parallel; the northern is called the *tropic of Cancer*, the southern the *tropic of Capricorn*. The tropics are the limits of the torrid zone, northward and southward; and within these boundaries alone is the sun ever seen vertical. The polar circles are two small circles, parallel to the equator (or equinoctial), at the distance of $66^\circ\ 32'$ from it, and $23^\circ\ 28'$ from the poles. The northern is called the *arctic*, the southern the *antarctic* circle. Parallels of latitude are small circles drawn through every ten degrees of latitude, on the terrestrial globe, parallel to the equator. Every place on the globe is supposed to have a parallel of latitude drawn through it, though there are generally only 16 parallels of latitude drawn on the terrestrial globe. The hour circle, on the artificial globe, is a small circle of brass, with an index or pointer fixed to the north pole. The hour circle is divided into 24 equal parts, corresponding to the hours of the day; and these are again subdivided into halves and quarters. The horizon is a great circle, which separates the visible half of the heavens from the invisible; the earth being considered as a point in the centre of the sphere of the fixed stars.

Horizon, when applied to the earth, is either sensible or rational. The sensible or visible horizon is the circle which bounds our view, where the sky appears to touch the earth or sea. The sensible horizon extends only a few miles; for example, if a man of six feet high were to stand on a large plane, or on the surface of the sea, the utmost extent of his view, upon the earth or the sea, would be only a very few miles. The rational or true horizon is an imaginary plane, passing through the centre of the earth, parallel to the sensible horizon. It determines the rising and setting of the sun, stars, and planets. The wooden horizon, circumscribing the artificial globe, represents the rational horizon on the earth. This horizon is divided into several concentric circles, arranged in the following order:—One contains the 32 points

of the compass, divided into half and quarter points. The degrees in each point are to be found in the amplitude circle. Another contains the 12 signs of the zodiac, with the figure and character of each sign; and another contains the days of the month, answering to each degree of the sun's place in the ecliptic, and the 12 calendar months.

The cardinal points of the horizon are east, west, north, and south. The cardinal points in the heavens are the zenith, the nadir, and the points where the sun rises and sets. The cardinal points of the ecliptic are the equinoctial and solstitial points, which mark out the four seasons of the year; and the cardinal signs are, ♈ Aries, ♋ Cancer, ♎ Libra, and ♑ Capricorn. The zenith is a point in the heavens exactly over head, and is the elevated pole of our horizon. The nadir is a point in the heavens exactly under our feet, being the depressed pole of our horizon, and the zenith or elevated pole, of the horizon of our antipodes. The pole of any circle is a point on the surface of the globe, 90° distant from every part of the circle. Thus the poles of the world are 90° from every part of the equator; the poles of the ecliptic (on the celestial globe) are 90° from every part of the ecliptic, and 23° 28′ from the poles of the equinoctial; consequently they are situated in the arctic and antarctic circles.

Every circle on the globe, whether real or imaginary, has two poles diametrically opposite to each other. The equinoctial points are Aries and Libra, where the ecliptic cuts the equinoctial. The point Aries is called the *vernal equinox*, and the point Libra the *autumnal equinox*. When the sun is in either of these points, the days and nights on every part of the globe are equal to each other. The solstitial points are Cancer and Capricorn. When the sun enters Cancer, it is the longest day to all the inhabitants on the north side of the equator, and the shortest day to those on the south side. When the sun enters Capricorn, it is the shortest day to those who live in north latitude, and the longest day to those who live in south latitude. A hemisphere is half the surface of the globe; for every great circle divides the globe into two hemispheres. The horizon divides the upper from the lower hemisphere in the heavens; the equator separates the northern from the southern on the earth; and the brass meridian, standing over any place on the terrestrial globe, divides the eastern from the western hemisphere. The latitude of a place, on the terrestrial globe, is its distance from the equator in degrees, minutes, or geographical miles, &c., and is reckoned on the brass meridian, from the equator towards the north or south pole.

The quadrant of altitude is a thin piece of brass, divided upwards from 0 to 90°, downward, from 0 to 18°; when used, it is generally screwed to the brass meridian. The upper divisions determine the distances of places on the earth, the distances of the celestial bodies, their latitudes, &c.; and the lower divisions are applied to finding the beginning, the end, and duration of twilight. The longitude of a place, on the terrestrial globe, is the distance of the meridian of that place from the first meridian, reckoned in degrees and parts of a degree, on the equator. Longitude is either eastward or westward according as a place is to the east or west of the first meridian. No place can have more than 180°, or half the circumference of the globe. (See LONGITUDE.)

Hour circles are the same as meridians. They are drawn through every 15° of the equator, each answering to an hour. The brass meridian and these circles always correspond. The crepusculum, or twilight, is that faint light which we perceive before the sun rises and after he sets. It is produced by the rays of light being refracted in their passage through the earth's atmosphere, and reflected from the different particles thereof. The twilight is supposed to end in the evening, when the sun is 18° below the horizon. The angle of position between two places on the terrestrial globe is an angle at the zenith of one of the places, formed by the meridian of that place, and a vertical circle passing through the other place, measured on the horizon, from the elevated pole towards the vertical circle. Rhumbs are the divisions of the horizon into 32 parts, called the *points of the compass*. We subjoin a few problems illustrative of the use of the globes.

Problem 1.—*To find the latitude of any place.*—Rule. Turn the globe till the place comes to the graduated edge of the brazen meridian, and the degree on the meridian with which the place corresponds is the latitude north or south, as it may be north or south of the equator.

Problem 2.—*To find the longitude of any place.*—Rule. Turn the globe till the place comes to the brazen meridian, and the degree on the equator, intersected by the brazen meridian, shows the longitude.

Problem 3.—*To find any place on the globe, having the latitude and longitude of that place given.*—Rule. Find the longitude of the given place on the equator, bring it to that part of the brass meridian which is numbered from the equator towards the poles; and then, under the given latitude, on the brass meridian, you will find the place required.

Problem 4.—*To find the difference of latitude of any two places.*—Rule. If the places are in the same hemisphere, bring each to the meridian, and subtract the latitude of the one from that of the other; if in different hemispheres, add the latitude of the one to that of the other, and the sum will show the difference of latitude.

Problem 5.—*To find the difference of longitude between any two places.*—Rule. Bring one of the places to the brazen meridian; mark its longitude; then bring the other place to the meridian, and the number of degrees between its longitude and that of the first mark is the difference of longitude. When this sum exceeds 180°, take it from 360°, and the remainder will be the difference of longitude.

Problem 6.—*To find the distance between two places.*—Rule. When the distance is less than 90°, lay the quadrant of altitude over both the places; so that the division marked O may be on one of the places; then the degree cut by the other place will show the distance in degrees. Multiply these degrees by 69½, and the product will be the distance in English miles. The distance between two places, with the angle of position, may be found, at the same time, in the following manner: Elevate the globe for one of the places, bring it to the meridian, screw the quadrant of altitude over it; then move the quadrant till it come over the other place, and observe what degree of it this last place cuts. Subtract this distance from 90°, and the remainder will be the distance in degrees. The quadrant of altitude, on the horizon, will now show the angle of position. When the distance is greater than 90°, find the antipodes of one of the places, and measure the distance between this and the

other place with the quadrant of altitude. Subtract this distance from 180, and the remainder will be the whole distance required. *When the angle of position is required*, this case may be performed thus: 1. Elevate the globe for the antipodes of one of the places, and, having fixed the quadrant over it, bring its edge over the other place, and add the degree cut by it to 90°, and the sum will be the distance required. 2. The quadrant will show the position; only, west must be read for east; east for west; north for south; and south for north.

Problem 7.—The hour being given at any place, to find what hour it is in any other part of the world.—Rule. Bring the place, at which the time is given, to the meridian; set the index to the given hour; then turn the globe till the other place comes to the meridian, and the index will show the time required.

The earth turns round on its axis from the west towards the east, and causes a different part of its surface to be successively presented to the sun. When the meridian of any place is directly opposite to the sun, it is then noon to all places on that meridian. Meridians towards the east come opposite to the sun sooner than those towards the west; and hence the people there have noon much sooner, and all the other hours of the day will be proportionably advanced. The earth takes 24 hours to turn on its axis, and the rate at which it turns every hour may be found, by dividing 360° by 24; the quotient, 15, is the number of degrees the earth turns in an hour. Hence it is that a place lying 15° to the east of another will have noon one hour sooner; if it is 30° or 45°, it will have noon two or three hours sooner than the other; and so on, in the same proportion, for all places farther removed. Places that are situate 15°, 30°, or 45°, to the west of that place at which it is noon, will have noon one, two, or three hours later; and so on, in the same proportion.

Problem 8.—To adjust the globe for the latitude, zenith, and sun's place.—Rule. For the *latitude:* elevate the pole above the horizon according to the latitude of the place, and the globe will be adjusted for the latitude. For the *zenith:* screw the quadrant of altitude on the meridian, at the given degree of latitude, counting from the equator towards the elevated pole, and the globe will be rectified for the zenith.—For the *sun's place:* find the sun's place on the horizon, and then bring the place which corresponds thereto, found on the ecliptic, to the meridian, and set the hour index to 12 at noon; then will the globe be adjusted for the sun's place.

Problem 9.—To find the sun's declination.—Rule. Bring the sun's place for the given day to the brass meridian, and the degree over it will be the declination sought; or bring the day of the month marked on the *analemma* to the brass meridian, and the degree over it will be the declination, as before. 1. The declination of the sun being its distance north or south from the equator, this problem is exactly the same as that for finding the latitude of a place. 2. The greatest north declination, 23° 28′, is when the sun enters Cancer, June 21st. The greatest south declination, 23° 28′, is when it enters Capricorn, December 21st.

Problem 10.—To find the sun's rising and setting for a given day at a given place.—Rule. Elevate the globe for the sun's declination; bring the given place to the meridian; set the index to 12, and turn the globe till the given place comes to the eastern edge of the horizon; then the index will show the time of the sun's rising. Next bring the given place to the western edge of the horizon, and the index will show the hour at which the sun sets. If the hour circle have a double row of figures, make use of that which increases towards the east; the sun's rising and setting may then be found at once, by bringing the place only to the eastern edge of the horizon; for the index will point on one row to the hour of rising, and on the other (that which increases towards the west) to the hour of setting. *By this problem may be found the length of the day and night.* Double the time of the sun's setting, and it will give the length of the day. Double the time of the sun's rising, and it will give the length of the night.

Problem 11.—To find all those places in the torrid zone to which the sun is vertical on a given day.—Rule. Find the sun's place for the given day, bring it to the meridian, mark the declination, and turn the globe round, when all those places which pass under that mark of the meridian, will have the sun vertical on the given day. By the analemma, bring the day of the month, marked upon the analemma, to the brazen meridian, and mark the declination; then the places will be found as above.

Problem 12.—The day, hour, and place being given, to find at what places of the earth the sun is then rising and setting, where it is noon, and where midnight.—Rule. Find the place to which the sun is vertical at the given hour, bring the same to the meridian, and adjust the globe to a latitude equal to the sun's declination. Then, to all places under the western side of the horizon, the sun is rising; to those above the eastern horizon, the sun is setting; to all those under the upper half of the brazen meridian, it is noon; and to all those under the lower half, it is midnight.

Problem 13.—To show, by the globe, the cause of day and night.—The sun shines upon the earth, and illuminates that half only which is turned towards him: the other half is in darkness. But, as the earth turns round on its axis from west to east once in 24 hours, every meridian upon the earth will, in that time, successively be presented to the sun, and be deprived of its light again. Rule. Elevate the globe for the sun's declination, so that the sun may be in the zenith, and the horizon will be the terminator, or boundary circle, of light and darkness: that half of the earth above the horizon enjoys light; that half below the horizon will be in darkness.—Put a patch upon a globe, to represent any place, turn the globe round from west to east, and, when the place comes to the western side of the horizon, the sun appears to the inhabitants of that place to be rising in the east; but it is more properly the inhabitants of that place rising in the west. Go on to turn the globe round, and the place will ascend higher towards the meridian in a contrary direction. When the place has arrived at the meridian, it will then be noon there, and the sun will be at his greatest altitude for that day. Continue to turn the globe, and the place will gradually recede from the meridian, and decline towards the eastern horizon, which will cause the appearance of the sun descending towards the west. When the place has arrived at the eastern horizon, as it is then going below the boundary of light and darkness, the sun will appear to be setting in the west. The place being now at a greater distance than 90° from that point where the sun is vertical is deprived of his light,

and continues in darkness till, by the revolution of the earth, it arrives again at the western horizon, when the sun will appear to rise as before. The sun is obviously rising at the same time to all places on the western side of the horizon, and setting at the same time to all places on the eastern side of the horizon.

Problem 14.—*To show, by the globe, the cause of the variety of the seasons.*—When the sun is in the equator, the horizon will represent the terminator, or boundary circle of light and darkness; and, the poles being made to coincide with it, we shall have a fair representation of the two seasons, spring and autumn; for, its rays then extending 90° every way from the vertical point, both poles will be illuminated. When the sun is in the tropic of Cancer, being 23½° farther to the north than before, his rays will extend 23½° beyond the north pole, on the opposite meridian: they will not, however, reach the south pole by 23½°; they will extend to the antarctic only, being 90° distant from the tropic of Cancer: hence, to make the horizon the terminator in this case, the north pole must be elevated 23½° above the horizon, and we shall have the summer season to Europeans.

When the sun is in the tropic of Capricorn, the reverse of this takes place; for the sun's rays then extend 23½° beyond the south pole, on the opposite meridian, and only as far north as the arctic circle: hence, to make the horizon the terminator in this case, the south pole must be elevated 23½° above the horizon, and we shall have the winter season to Europeans. The problems thus given are only to be considered as specimens of what may be performed. On the terrestrial globe, Butler describes 57; while, on the celestial sphere, the number and variety are still much greater. It is said that Anaximander of Miletus, a pupil of Thales, who flourished about the 50th Olympiad (580 B. C.), invented the terrestrial globe. That Ptolemy had an artificial globe, with the universal meridian, appears from his *Almagest*. The ancients likewise made celestial globes. Among the moderns, several have distinguished themselves in the construction of globes. The Venetian Coronelli (who died 1718) prepared, in 1683, with the assistance of Claudius Molinet and other Parisian artists, a terrestrial globe, for Louis XIV., twelve Parisian feet in diameter. The same artist made a celestial globe of the same size. Funk, in Leipsic, published in 1780 models in the form of cones (*coniglobia*), as substitutes for celestial globes. These cones may be made almost as serviceable as globes, and are incomparably cheaper. Some of the best modern globes are those made since 1790, at Nuremberg, after the direction of the famous observer Bode. Newton's globes are very good. Globes have been lately made in this country, for the use of learners, with nothing but the meridians and parallels of latitude drawn indelibly on them. They are covered with a substance on which drawings can be made with a slate pencil, and easily effaced. In the United States, white globes have been prepared, on which the pupil can draw with a black-lead pencil, and rub out the work at pleasure. Either sort must be highly useful in schools where geography is carefully studied.

Among the most remarkable globes in existence, that of Gottorp, in the Academy of Science of Petersburg, is worthy of notice. This is a large concave sphere, eleven feet in diameter, containing a table and seats for twelve persons, to whom the inside surface represents the visible phenomena of the heavens. The stars are distinguished by gilded nails, according to their respective magnitudes, and arranged in groups, as the different constellations require. The outside is a terrestrial globe, representing the land and water on the surface of the earth. It is called the *globe of Gottorp*, from being substituted for one originally made in that place, which, with inconceivable labour, was conducted upon rollers and sledges, over snow, and through forests, to Riga, and thence by sea to Petersburg. In 1751, it was consumed by fire, and from its iron plates and materials the present globe was made. But, large as these globes are, they become diminutive when compared with the sphere constructed by the late Doctor Long. This is eighteen feet in diameter; and it will enable thirty persons to sit within its concavity, without any inconvenience. The entrance is over the south pole, by six steps. This wonderful machine stands in Pembroke Hall, in the University of Cambridge. All the constellations and stars of the northern hemisphere, visible at Cambridge, are painted upon plates of iron, which, joined together, form one concave surface. Unfortunately, it is now very much damaged. There is a terrestrial globe exhibiting in Paris, sixty feet in diameter, admirably executed: it will contain 100 persons. It cost 5000*l.*

The Celestial Globe. The general definitions given of the terrestrial globe apply also to the celestial, the various circles of which are more aptly illustrated by the armillary sphere, which is well adapted to give youth just notions of those imaginary circles which astronomers have applied to what is vulgarly called the *concave sphere of the heavens;* but, by means of those circles, we investigate, with the nicest accuracy, the motions of the celestial bodies. There are six great circles of the sphere, which require particular attention, and on this account we may briefly recapitulate their general arrangement. They are the horizon, the meridian, the equator, the ecliptic, the equinoctial colure, and the solstitial colure. The sphere is contained in a frame, on the top of which is a broad circle, representing the meridian. It is suspended on two pins, at opposite points of the meridian. These pins are a continuation of the axis of the sphere both ways, and, as the sphere turns round upon them, they are considered as poles, north and south. The equator goes round the sphere, exactly in the middle, between the two poles. The ecliptic, the colures, the tropics, and polar circles, have been already defined, and are easily discovered.

The horizon is graduated, according to the division of the circle, into quadrants and degrees; and, to refer celestial objects to the horizon, we have also the points of the compass laid down. Hence the amplitude, or distance, of heavenly bodies, from the east and west points, and their azimuth, or distance from the meridian, are reckoned on the horizon of the armillary sphere. The graduation of the equator enables us to fix the right ascension of celestial, and the longitude of terrestrial objects. The graduation of the ecliptic serves to indicate, in the armillary sphere, the latitude and longitude of celestial bodies. The colures are, in a manner, the limits of the year, pointing out the seasons by the two opposite points of the ecliptic. The hour circle tells us in what time any motion of the earth, in the centre, is performed. In fine, many details of the science may be pleasingly and popularly illustrated by this contrivance.

By placing small patches of paper on the different circles, to represent stars, we perceive, that those which are farthest from the poles will describe the greatest circles; and that the greatest circles are described by those stars situated in the celestial equator. A star has acquired its greatest elevation when it comes to the upper semicircle of the meridian, and its greatest depression when it is at the lower circle of the meridian: the meridian bisects its arc of apparition. Some circles of revolution are wholly above, others entirely below, the horizon; therefore the patches on those circles show us which stars descend below, or which never ascend above the horizon.—And any object, whose circle of revolution is on the same side of the equator with the elevated pole, is longer visible than it is invisible; the contrary holds true if it be on the other side of the equator.

The following definitions are more immediately applicable to the celestial globe: The declination of the sun, of a star, or planet, is its distance from the equinoctial, northward or southward. When the sun is in the equinoctial, he has no declination, and enlightens half the globe, from pole to pole. As he increases in north declination, he gradually shines farther over the north pole, and leaves the south pole in darkness: in a similar manner, when he has a south declination, he shines over the south pole, and leaves the north pole in darkness. The greatest declination the sun can have is 23° 28′; the greatest declination a star can have is 90°, and that of a planet 30° 28′, north or south. The latitude of a star, or planet, is its distance from the ecliptic, north or south, reckoned towards the pole of the ecliptic, on the quadrant of altitude. Some stars, situate in and about the pole, have 90° of latitude; the planets have only 8°; and the sun, being always in the ecliptic, has no latitude. The longitude of a star, or planet, is reckoned by the degrees of the ecliptic, from the point Aries round the globe. On the celestial globe, the longitude of the sun corresponds with the sun's place on the terrestrial globe.

The right ascension of the sun, or a star, is that degree of the equinoctial which rises with the sun, or a star, in a right sphere, and is reckoned from the equinoctial point Aries eastward round the globe. Oblique ascension of the sun, or a star, is that degree of the equinoctial which rises with the sun, or a star, in an oblique sphere, and is likewise counted from the point Aries eastward round the globe. Oblique descension of the sun, or a star, is that degree of the equinoctial which sets with the sun, or a star, in an oblique sphere. The ascensional or descensional difference is the difference between the right and oblique ascension, or the difference between the right and oblique descension; and, with respect to the sun, it is the time he rises before six in the spring and summer, or sets before six in the autumn and winter. The angle of position of a star is an angle formed by two great circles intersecting each other in the place of the star, the one passing through the pole of the equinoctial, the other through the pole of the ecliptic.

The poetical rising and setting of the stars is so called because the ancient poets referred the rising and setting of the stars to the sun. When a star rose with the sun, or set when the sun rose, it was said to rise and set *cosmically*. When a star rose at sunsetting, or set with the sun, it was said to rise and set *achronically*. When a star first became visible in the morning, after having been so near the sun as to be hid by the splendour of his rays, it was said to rise *heliacally*; and when a star first became invisible in the evening, on account of its nearness to the sun, it was said to set *heliacally*. A constellation is an assemblage of stars, on the surface of the celestial globe, circumscribed by the outlines of some assumed figure, as a bull, a bear, a lion, &c. This division of the stars into constellations directs us to any part of the heavens where a particular star is situated. The zodiacal constellations are 12 in number; the northern constellations 41, and the southern 46, making in the whole 99. The largest stars are called *stars of the first magnitude*. Those of the sixth magnitude are the smallest that can be seen by the naked eye.

Sir John Byerley has recently introduced into England a globe of a new and important character, invented by M. Guesney, an advocate of Coutances in Normandy, and described by him in a work entitled, *Mouvement Heliaque*, Paris, 1825. Many of the more important phenomena of geology and physical geography have given birth to the wildest theories. M. G. being led to regard them as produced by the precession of the equinoxes (see PRECESSION), attempted their solution on scientific bases. Unfortunately, M. G. is a sworn enemy of the Newtonian system, and, while his whole theory is grounded on the precession of the equinoxes, he denies the cause of that precession, and affirms that the earth is perfectly spherical! His work abounds with errors quite as easy to refute, but he has the great and exclusive merit of having first had the idea of constructing a terrestrial globe in harmony with the celestial, by tracing the system of the ecliptic upon it, as upon the celestial globe.

We may here observe, that the whole of the appearances in the heavens are to be referred to the two motions of the earth. The polar star is not polar to any planet but our own; and the poles of the ecliptic in the folds of Draco and in the Dorado are only so in reference to the earth. The axes of the world, as they are called, or those of the ecliptic and the equator, are two lines crossing each other *in the centre of the earth*, at an angle of 23° 28′, and extending to the heavens; but, we repeat it, they do not pass through the centres of any other planets; and are, therefore, to be referred to the earth alone.

The points where these lines pass through the surface of the earth are the poles on which its motions are performed, the movement of rotation, or diurnal motion, on the poles of the equator, and the movement of translation, or annual motion, on the poles of the ecliptic. M. Guesney's great difficulty was, to fix the seat of the poles of the ecliptic on the terrestrial globe. In this he received no aid from astronomers, who declare the ecliptic to be a circle in the heavens, and to have no reference whatever to the earth, forgetting that, as the plane of the ecliptic passes through the centre of the earth, *it must cut its surface somewhere:* to determine those points, then, and consequently the poles of the terrestrial ecliptic, was the object of M. Guesney. He found that the magnetic needle and its dip were both directed to one point on the globe near the polar circle at the back of Iceland, precisely on the first meridian adopted by order of Louis XIII., passing through the island of Ferro. He found that, by supposing the seat of the pole of the ecliptic there, it gave a

satisfactory solution of many, hitherto inexplicable phenomena; he therefore fixed it there by approximation. Sir J. B. appears to be the only scientific person who has taken the trouble to sift the wheat from the chaff, and on this basis to erect a theory embracing the principal phenomena. Not, however, satisfied with approximation, where mathematical accuracy was evidently attainable, he endeavoured to ascertain precisely the poles of the terrestrial ecliptic, when, fortunately, he found that Laplace, pursuing another object, had already solved the problem.

To avoid the confusion of every maritime nation using a different first meridian, Laplace wished them to take that "of which the midnight corresponds with the instant when the great axis of the ecliptic is perpendicular to the right line of intersection of the equator and ecliptic, which meridian is 166° 46′ 12″ east of Paris," or 169° 6′ 27″ east of Greenwich Observatory.

On the authority, therefore, of the greatest astronomer of any age, Sir J. B. has had a terrestrial globe prepared by Mr. Newton, with the system of the ecliptic described on the poles as fixed by Laplace; the north pole of the ecliptic being in the polar circle, and the winter solstitial colure, or first meridian, 10° 53′ 35″ west of Greenwich. A circle drawn from this pole as a centre, on a radius of 23° 28′, will pass through the pole of the earth, and trace its line of motion round the pole of the ecliptic, in 25,920 years.

This revolution of the pole of the equator round that of the ecliptic is admitted by all astronomers to take place in the *heavens*, but not in the earth. They admit, too, that the axis of the ecliptic is fixed and immovable, the ecliptic being so; but they have not yet shown how a right line intersecting another fixed right line at a given angle shall move round the latter at its extremity, and not at a given distance from the point of intersection! Assuming, then, that the pole of the equator rovolves round the pole of the *terrestrial ecliptic*, it remains to show a few of the terrestrial effects of such motion.

By inspection of the globe, we find that the pole of the equator is now at nearly its greatest distance from western Europe; that it is advancing at the rate of about 394 yards annually on North America, and will pass through Lancaster Straits, Hudson Straits, over Resolution Isle, enter Europe at Cape Finisterre, pass over Bilbao and the northern frontier of Spain, through France over Toulouse, through Lombardy over Milan, through Germany over Vienna, and pass into Russia over Moscow, &c. &c. It is found that the solstitial colures are almost entirely in the ocean, cutting only a small portion of western Africa and a portion of Kamtschatka, and proceeding without interruption until they meet the lower part of New Zealand.

On inspecting the globe farther, we find that Kamtschatka was, at a given period, within the tropics, which accounts for tropical fossils being found in the polar regions; and that the Oural Mountains were formerly in the latitude of Mexico, which explains why the precious metals are found in such high latitudes, and why the same precious stones are found in Mexico and the Oural Mountains. We find also that the direction of the straits in the higher latitudes run from west to east, or in the direction of the waters of the pole. The debris of mountains are found in the same direction in England, France, Italy, Scandinavia, &c. The plains of Lombardy are covered with Alpine debris, and, in Scandinavia, masses of 50,000 tons have been transported (Dr. Buckland fancies on the back of an iceberg) by the immense force of the Polar Ocean.

The radius of the earth at the equator is about 65,000 feet greater than the polar radius, owing to the centrifugal force (which is as the radii of the parallels of latitude). And, as the pole moves through 46° 56′ of latitude in 12,960 years, in that lapse of time one part of the equator will be carried 46° 56′ into the southern hemisphere. At that period all western Europe will be buried under the waters of the pole (forming the period of a deluge), as it was at three distinct periods, at intervals of nearly 26,000 years; which ascertains the existence of the globe in its present state (which was probably its primitive) for 70,000 years. This change of the plane of the equator is probably the cause of all the great phenomena; it changes the latitude from polar to tropical regions, and thus renders a change in the action of the centrifugal force; and, from whatever part the pole is receding, the centrifugal force is increasing, which produces an alteration of surface; in whatever place it is advancing there is a consequent depression. There is thus a daily tendency to elevation in some parts, and to depression in others; and to this cause Sir J. B. attributes earthquakes and volcanic action. According to this theory, as the elevation and depression must be greatest in the direction of the motion of the pole, so ought the degree of volcanic action to be. On inspecting the globe, we find this to be the case, and that volcanic action is greatest on the meridians of South America and the Philippine Isles. Where no elements of combustion exist we have eruptions of mud, &c.

The difference between the earth's radius at the equator and at 45° is 5340 French toises, or about 33,000 English feet. Now, the equator changing its position nearly 47°, it follows that in the solstitial colure the present position of the equator will be depressed at least 33,000 feet. This will readily account for marine fossils being found in Chimborazo, 15,500 feet above the surface of the ocean.

The above is a brief outline of the system to which Sir John Byerley intends shortly to call the attention of the public. He courts inquiry; for, if the theory be well founded, it will entirely remodel the science of physical geography; and, on this account, we have requested Sir John to furnish us with the preceding abstract of his theory, which our confined limits must render naturally imperfect.

GLOTTIS (from γλωττα, the tongue); the superior opening of the larynx at the bottom of the tongue.

GLUCINE, or GLUCINA; the name of a very rare earth, found only in three rare minerals, beryl or emerald, euclase and chrysoberyl. It is usually procured from the beryl, in which it exists in the proportion of fourteen per cent., combined with silex and alumine. The process for obtaining it pure is as follows:—The mineral is reduced to an exceedingly fine powder, mingled with three times its weight of carbonate of potash, and exposed to a strong heat for half an hour. The fused mass is then dissolved in dilute muriatic acid, and the solution evaporated to perfect dryness, by which means the silex is rendered perfectly insoluble. The alumine and glucine are then redissolved in water, acidulated with muriatic

acid, and thrown down together by pure ammonia. The precipitate, after being well washed, is macerated with a large excess of carbonate of ammonia, by which glucine is dissolved; and, on boiling the filtered liquid, carbonate of glucine subsides, which, on being heated to redness, affords pure glucine. In this condition, it is white, tasteless, without odour, and quite insoluble in water. Specific gravity, 3. Vegetable colours are not affected by it. It is supposed, by analogy, to be the oxide of a metal, and its supposed metallic base is called *glucinum*. The salts which glucine forms with acids have a sweetish taste.

Carbonate of Glucine, obtained by double decomposition, is precipitated in a soft state, and is not easily dried, is insipid, insoluble in water, and is not rendered soluble by an excess of acid.

Nitrate of Glucine cannot be crystallized, but by evaporation forms a gelatinous mass, which is very deliquescent.

Sulphate of Glucine is difficultly crystallizable; its taste is saccharine and astringent; it is very soluble in water, its solution assuming by concentration the consistence of a syrup.

Phosphate of Glucine is in the form of a white powder, or of a viscous substance, insipid, and insoluble in water, but rendered soluble by an excess of acid.

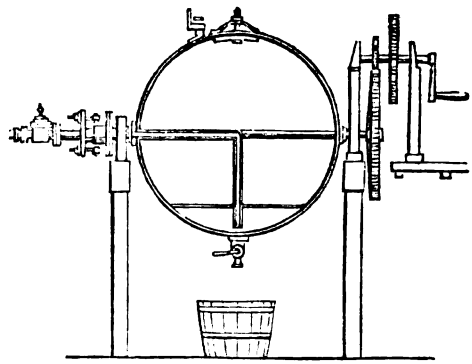
Muriate of Glucine is soluble in water, and by evaporation can be obtained in small crystals.

Fluate of Glucine is obtained by mixing fluate of potash and muriate of glucine: it is thrown down in the form of a gelatinous precipitate.

GLUE, among artificers; a tenacious, viscid matter, which serves as a cement. Glues are of different kinds, according to the various uses they are designed for, as the common glue, glove glue, parchment glue, isinglass glue, &c. The common or strong glue is made of the skins of animals, as oxen, cows, calves, sheep, &c.; and the older the animal is the better is the glue made of its hide. Indeed, whole skins are rarely used for this purpose, but only the shavings, parings, or scraps of them; or the feet, sinews, &c. Those who make glue of parings, first steep them two or three days in water, then wash them well out, boil them to the consistence of a thick jelly, which they pass, while hot, through osier baskets, to separate the impurities from it, and then let it stand some time, to purify it farther; when all the filth has settled to the bottom of the vessel, they melt and boil it a second time. They next pour it into flat frames or moulds, whence it is taken out pretty hard and solid, and cut into square pieces or cakes. They afterwards dry it in the wind, in a sort of coarse net; and at last string it, to finish its drying. The best glue is that which is oldest; and the surest way to try its goodness is, to lay a piece to steep three or four days, and if it swell considerably without melting, and when taken out resume its former dryness, it is excellent. In some large manufactories, it is now found advantageous to employ steam-pipes for heating the glue, which is by this means better, while all danger of fire is prevented.

A glue that will hold against fire and water, may be made thus:—Mix a handful of quick lime with four ounces of linseed oil, boil them to a good thickness, then spread the paste on tin plates in the shade, and it will become exceedingly hard, but may be dissolved over a fire as glue.

A patent has been obtained for the manufacture of glue from bones, which promises to be of considerable advantage. The apparatus is represented beneath.



The patentee employs steam at a high pressure, which is conveyed into the globular metallic vessel by the hollow axis. In this also is placed the bones from which the gelatine is to be extracted. It is afterwards evaporated, and dried on nets in the ordinary way. Motion is communicated to the globe by the wheel-work and winch.

Parchment glue is made by gently boiling shreds of parchment in water, in the proportion of one pound of the former to six quarts of the latter, till it is reduced to one quart: the fluid is then strained from the dregs, and afterwards boiled to the consistence of glue. Isinglass glue is made in the same way; but this is improved by dissolving the isinglass in alcohol, by means of a gentle heat.

GLUTEN; a vegetable compound, procured by repeatedly washing wheat flour in a large quantity of water, by which means the starch is dissolved, leaving the gluten behind in a very tenacious, ductile, somewhat elastic state, and possessed of a brownish-gray colour. It has scarcely any taste, and is insoluble in water, alcohol, and ether, but is taken up by acids and alkalies. The acid solution is precipitated by an alkali, and, reciprocally, the alkaline solution by an acid. Dried by a gentle heat, it contracts its volume, and becomes hard and brittle. Its products with fire, or nitric acid, are nearly the same as those of gum and sugar. Gluten is present in most kinds of grain, such as wheat, barley, rye, oats, peas, and beans; but the first contains it in far the largest proportion, which is the reason that wheaten bread is more nutritious than that made with other kinds of flour; for, of all vegetable substances, gluten appears to be the most nutritive. It is to the presence of gluten that wheat flour owes its property of forming a tenacious paste with water, to which cause is due the formation of light spongy bread. The carbonic acid, which is disengaged during the fermentation of the dough, being detained by the viscid gluten, distends the whole mass, and thus produces the rising of the bread. Good wheat flour contains from 8 to 10 per cent. of gluten.

Gluten consists of two distinct principles; to one of which has been applied the name of *gliadine*, gluten, and to the other that of *zymome*, a ferment. To obtain these principles, the gluten is boiled repeatedly in alcohol, which dissolves the gliadine, and leaves the zymome in a pure state. On mixing the powder of guaiacum with the latter substance, a beautiful blue colour instantly appears; and the

same phenomenon ensues, though less rapidly, when it is kneaded with gluten, or the flour of good wheat moistened with water. With bad flour, the gluten of which has suffered decomposition, the blue tint is scarcely visible. The intensity of the colour thus produced is entirely dependent on the relative quantity of zymome contained in the flour; and, since the quantity of zymome is proportional to the quantity of gluten, the proportion of the latter, and therefore the quality of the flour, is tested by the action of the guaiacum.

GNOMON, in *astronomy*, is an instrument or apparatus for measuring the altitudes, declinations, &c., of the sun and stars. The gnomon is usually a pillar, or column, or pyramid, erected upon level ground, or a pavement. For making the more considerable observations, both the ancients and moderns have made great use of it, especially the former; and many have preferred it to the smaller quadrants, both as more accurate, and more easily made and applied. The most ancient observation of this kind extant is that made by Pytheas, in the time of Alexander the Great, at Marseilles, where he found the height of the gnomon was, in proportion to the meridian shadow at the summer solstice, as 213½ to 600; just the same as Gassendi found it to be, by an observation made at the same place, almost 2000 years after, viz. in the year 1636. This method of observation, however, is by no means accurate, as is proved by the following deficiencies in the ancient observations made in this manner: 1. The astronomers did not take into account the sun's parallax, which makes his apparent altitude less than it would be if the gnomon were placed at the centre of the earth. 2. They neglected refraction, by which the apparent height of the sun is somewhat increased. 3. They made their calculations as if the shadows were terminated by a ray coming from the sun's centre; whereas it is bounded by one coming from the upper edge of his limb.—These errors, however, may be easily allowed for; and, when this has been done, the ancient observations are generally found to coincide nearly with those of the moderns.

GNOMON, in *dialling*, is the style-pin of a dial, the shadow of which points out the hours. This is always supposed to represent the axis of the world, to which it is therefore parallel, or coincident, the two ends of it pointing straight to the north and south poles of the world.

GOITRE. See WEN.

GOLD is the most precious metal employed in commerce. It is exceedingly soft and flexible, but its tenacity is sufficiently great to sustain, in a wire one-tenth of an inch in diameter, 500 lbs. weight without breaking. In hardness it is superior to lead and tin, but inferior to iron, copper, platina, and silver. Its lustre does not equal that of steel, platina, or silver, but it surpasses the other metals in this respect. It may be exposed for any length of time to the atmosphere, without suffering the least change. It is also unalterable in the common fire; but on being exposed to powerful burning mirrors, or to the heat of the oxy-hydrogen blowpipe, it not only melts, but even rises in vapour.

Gold is not readily oxidized or dissolved by any of the pure acids. Its best solvents are chlorine and nitro-muriatic acid; and, according to Sir H. Davy, the chlorine is the agent in both cases, since the nitro-muriatic acid does not dissolve gold, except when it gives rise to the formation of chlorine. It is to be inferred, therefore, that the chlorine unites directly with the gold, and that the compound formed is a chloride of gold. There is no inconvenience, however, in regarding it as a muriate, since re-agents act upon it as if it were such. The gold is precipitated from its solvent by a great number of substances. Lime and magnesia precipitate it in the form of a yellowish powder. Alkalies exhibit the same appearance; but an excess of alkali redissolves the precipitate. The precipitate of gold obtained by a fixed alkali appears to be a true oxide, and is soluble in the sulphuric, nitric, and muriatic acids; from which, however, it separates by standing. Gallic acid precipitates gold of a reddish colour, and very soluble in nitric acid, to which it communicates a fine blue colour. Ammonia precipitates the solution of gold much more readily than fixed alkalies. This precipitate, which is of a yellowish-brown colour, possesses the property of detonating with a very considerable noise, when greatly heated. It is known by the name of *fulminating gold*.

Most metallic substances precipitate gold from its solution in nitro-muriatic acid. Lead, iron, and silver precipitate it of a deep and dull purple colour; copper and iron throw it down in its metallic state. A plate of tin, immersed in a solution of gold, affords a purple powder, called the *purple powder of Cassius*, which is used to paint in enamel. Ether, naphtha, and essential oils take gold from its solvent, and form liquors, which have been called *potable gold*. The gold which is precipitated on the evaporation of these fluids, or by the addition of sulphate of iron to the solution of gold, is of the utmost purity. The principal use of gold, as is well known, is in coinage.—It has been with mankind, from time immemorial, the representative sign of every species of property. Even before the art of coining was invented, it passed for money in the condition in which it was found in the earth; and in this form it still enjoys a currency in many parts of Africa. It is rarely employed in a state of perfect purity, but is almost universally alloyed with copper, or with silver, in order to increase its hardness. The alloy of gold and silver is found already formed in nature, and is that most generally known. It is distinguishable from that of copper, by possessing a paler yellow than pure gold, while the copper alloy has a colour bordering upon reddish yellow. A variety of means are employed to judge of the quality of alloys, supposed to consist in part, or principally, of gold, without resorting to a regular analysis.

The art of gilding metals (see GILDING) depends upon the double property which mercury possesses, of amalgamating with gold, and of becoming volatile by heat, and thus quitting the gold, which adheres strongly to the metal upon which the mercurial amalgam has been spread. The composition of the amalgam generally used is eight parts of mercury to one of gold. The malleability and extreme divisibility of gold are the foundation of the art of *gold-beating;* and these two properties are so remarkable in this art, that natural philosophers are in the habit of quoting the results it furnishes, as examples of the divisibility of matter. Boyle has observed that a grain of gold, reduced to leaves, will cover a surface of 50 square inches; that each one of these square inches may be divided into 46,656 other little squares, and that, of course, the entire amount of surface de-

rived from one grain of gold is capable of being divided into 2,322,800 parts, each of which is visible to the naked eye.

In consequence of the wonderful extension which the gold-beater is enabled to give to this precious metal, it is employed for ornamental purposes to an extent which, from its comparative scarcity, would otherwise be impossible. Thus it is estimated that an equestrian statue, of the natural size, may be coated with a piece of gold not exceeding ten shillings and sixpence in value. The gilding of the dome of the *Hôtel des Invalids*, at Paris, cost about 5000*l*. And in India, where it is common to gild towers, bridges, gates, and colossal idols, it is known to be attended with still less expense.

The following is a short account of the ingenious art of *gold-beating*. The gold used is as pure as possible, and the operation is commenced with masses weighing about two ounces. These are beaten into plates six or eight inches long, by three-quarters of an inch wide. They are then passed between steel rollers, till they become long ribands, as thin as paper. Each one of these is now cut into 150 pieces, each of which is forged on an anvil, till it is about an inch square, after which they are well annealed. Each of the squares in this state weighs $6\frac{4}{10}$ grains, and in thickness is equal to $\frac{1}{768}$ of an inch. The 150 plates of gold thus produced from one mass are interlaid with pieces of very fine vellum, about four inches square, and about twenty vellum leaves are placed on the outsides; the whole is then put into a case of parchment, over which is drawn another similar case, so that the packet is kept close and tight on all sides. It is now laid on a smooth block of marble, or metal, of great weight, and the workman begins the beating with a round-faced hammer, weighing sixteen pounds; the packet is turned, occasionally, upside down, and beaten with strong but not acute strokes, till the gold is extended nearly to an equality with the vellum leaves. The packet is then taken to pieces, and each leaf of gold is divided into four with a steel knife. The 600 pieces thus produced are interlaid with pieces of animal membrane, from the intestines of the ox, of the same dimension and in the same manner as the vellum. The beating is continued, but with a lighter hammer, which weighs about twelve pounds, till the gold is brought to the same dimensions as the interposed membrane. It is now again divided into four, by means of a piece of cane, cut to an edge, the leaves being by this time so light that any accidental moisture, condensing on an iron blade, would cause them to adhere to it. The 2400 leaves hence resulting are parted into three packets, with interposed membrane as before, and beaten with the *finishing*, or *gold hammer*, weighing about ten pounds, till they acquire an extent equal to the former. The packets are now taken to pieces, and the gold leaves, by means of a cane instrument and the breath, are laid flat on a cushion of leather, and cut, one by one, to an even square, by a cane frame; they are lastly laid in books of twenty-five leaves each, the paper of which is previously smoothed, and rubbed with red bole, to prevent them from adhering.

Gold wire, as it is called, is, in fact, only silver wire gilt, and is prepared in the following manner. A solid cylinder of fine silver, weighing about 20lbs., is covered with thick leaves of gold, which are made to adhere inseparably to it by means of the burnisher: successive laminæ are thus applied, till the quantity of gold amounts to 100 grains for every pound troy of silver. This gilt silver rod is then drawn successively through holes made in a strong steel plate, till it is reduced to the size of a thick quill, care being taken to anneal it accurately after each operation. The succeeding process is similar to the former, except that a mixed metal, somewhat softer than steel, is employed for the drawing plates, in order to prevent the gilding from being stripped off; and no farther annealing is requisite after it is brought to be as slender as a crow-quill. When the wire is drawn as thin as is necessary, it is wound on a hollow copper bobbin, and carefully annealed by a very gentle heat: finally, it is passed through a flatting-mill, and the process is complete. According to Dr. Halley, 6 feet in length of the finest gilt-wire, before flatting, will counterpoise no more than a grain; and as the gold is not quite $\frac{1}{57}$ of the whole, a single grain of gold, thus extended, will be 345.6 feet long, and only the millionth part of an inch in thickness. (See METALLURGY.)

GOLDSMITH; an artist who makes vessels, utensils, and ornaments, in that metal. The work is either performed in the mould, or beaten out with the hammer, or other engine. All works that have raised figures are cast in a mould, and afterwards chased and finished: plates, or dishes, of silver or gold, are beaten out from thin flat plates, and tankards and other vessels of that kind are formed of plates soldered together, and their mouldings are beaten, not cast. The goldsmith makes his own moulds, and for that reason ought to be a good designer, and have a taste in sculpture: he also ought to know enough of metallurgy to be able to assay mixed metals, and to mix the alloy.

GONIOMETER; an instrument for measuring the angles of crystals.

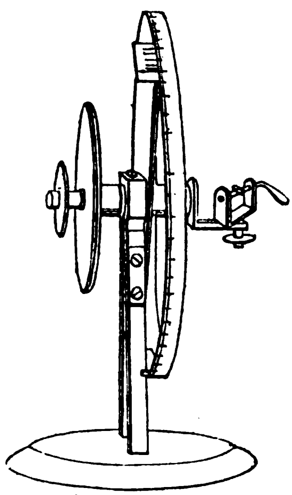
From the advances that have been made of late years in crystallography, a very large proportion of mineral substances may now be recognized, if we can ascertain the angular dimensions of their external forms, or the relative position of those surfaces that are exposed by fracture. But though the modifications of tetrahedrons, of cubes, and of those other regular solids, to which the adventitious aid of geometry could be correctly applied, was determined with the utmost precision; yet it was often a subject of regret, that our instruments for measuring the angles of crystals were not possessed of equal accuracy, and that in applying the goniometer to small crystals, where the radius in contact with the surface was necessarily very short, the measures, even when taken with a steady hand, would often deviate too much from the truth to determine the species to which a substance belonged.

A means of remedying this defect was suggested by Dr. Wollaston, by which in most cases the inclination of surfaces might be measured as exactly as could be wanted for common purposes; and, when the surfaces were sufficiently smooth to reflect a distinct image of distant objects, the position of faces only 1-50th of an inch in breadth might be determined with as much precision as those of any larger crystals.

For this purpose, the ray of light reflected from the surface is employed as radius, instead of the surface itself; and accordingly, for a radius of 1-50th of an inch, we may substitute either the distance of

the eye from the crystal, which would naturally be about twelve or fifteen inches; or, for greater accuracy, we may, by a second mode, substitute the distance of objects seen at a hundred or more yards from us.

The instrument consists of a circle graduated on its edge, and mounted on a horizontal axle, supported by an upright pillar. This axle, being perforated, admits the passage of a smaller axle through it, to which any crystal of moderate size may be attached by a piece of wax, with its edge, or intersection of the surfaces, horizontal and parallel to the axis of motion.



This position of the crystal is first adjusted, so that, by turning the smaller axle, each of the two surfaces whose inclination is to be measured will reflect the same light to the eye.

The circle is then set to zero, or 180°, by an index attached to the pillar that supports it.

The small axle is then turned till the farther surface reflects the light of a candle, or other definite object, to the eye; and, lastly (the eye being kept steadily in the same place), the circle is turned by its larger axle, till the second surface reflects the same light. This second surface is thus ascertained to be in the same position as the former surface had been. The angle through which the circle has moved is, in fact, the supplement to the inclination of the surfaces; but, as the graduations on its margin are numbered accordingly in an inverted order, the angle is correctly shown by the index, without the need of any computation.

It may here be observed that it is by no means necessary to have a clean uniform fracture for this application of the instrument to the structure of laminated substances; for, since all those small portions of a shattered surface that are parallel to one another (though not in the same plane) glisten at once with the same light, the angle of an irregular fracture may be determined nearly as well as when the reflecting fragments are actually in the same plane.

In this method of taking the measure of an angle, when the eye and candle are only ten or twelve inches distant, a small error may arise from parallax, if the intersection of the planes or edge of the crystal be not accurately in a line with the axis of motion: but such an error may be rendered insensible, even in that mode of using the instrument, by due care in placing the crystal; and, when the surfaces are sufficiently smooth to reflect a distinct image of objects, all error from the same source may be entirely obviated by another method of using it.

For this purpose, if the eye be brought within about an inch of the reflecting surface, the reflected image of some distant chimney may be seen inverted beneath its true place, and by turning the small axle may be brought to correspond apparently with the bottom of the house (or with some other distant horizontal line). In this position the surface accurately bisects the angle which the height of that house subtends at the eye (or rather at the reflecting surface); then, by turning the whole circle and crystal together, the other surface, however small, may be brought exactly into the same position; and the angle of the surfaces may thus be measured with a great degree of precision.

The inclination of the surfaces of a primitive crystal of carbonate of lime is stated, with great appearance of precision, to be 104° 28′ 40″; a result deduced from the supposed position of its axis at an angle of 45° with each of the surfaces, and from other erroneous circumstances of apparent harmony by simple ratios. But however strong the presumption might be that this angle, which by measurement approaches to 45°, is actually so, it must nevertheless be in fact about 45° 20′; for the inclination of the surfaces to each other is very nearly, if not accurately, 105°, as it was formerly determined to be by Huygens; and, since the measure of the superficial angle given by Sir Isaac Newton corresponds with this determination of Huygens, his evidence may be considered as a farther confirmation of the same result; for it may be presumed that he would not adopt the measures of others without a careful examination.

Gout, or Arthritis, a disease of adults, is sometimes regular, attended with the secretion of the superfluous earthy matter which is no longer necessary for the formation of the bones; sometimes irregular, when the vital powers are weakened, and the superfluous bony matter, instead of being carried off by the organs of secretion, is deposited beneath the skin, or accumulates internally, thus producing chalk-stones and various internal concretions. There are two principal causes of the gout—bad diet and suppression of perspiration. Frequent use of wine, in particular of acid wines, as well as the daily use of very nourishing, fat, and high-seasoned food, contributes chiefly to the production of the disease, both from the excess of nutritive and earthy matter, and from its exciting effects on the blood; since so great a quantity of nutritive matter is not required by the fully developed body, and is not assimilated by the weakened organs of digestion. The disease in these cases is called *podagra*, and returns at regular periods. (See Podagra.)

In spring, in autumn, and with many much oftener, violent pains are felt in or near the joint of the great toe; the part becomes inflamed, red, and swollen. A fever is usually connected with it, if the local inflammation re-acts upon the whole system of the blood. Among the poorer classes, the real gout is seldom met with; yet, even among these, overloading the stomach with poor and badly-cooked food, repeated exposure to cold, an accumulation of half-assimilated matter in the blood, and suppressed secretion, sometimes produce irregular gouty attacks, wandering pains, depositions of an extraordinary quantity of earthy matter in the limbs, and striking deformities. Gout and rheumatism are frequently confounded, but they are very different in their nature. Rheumatism attacks every age of life; gout only adults. Rheumatism is an inflammatory state of the system of muscles and tendons; in the gout, this inflammation is in the joints, the capsular ligaments,

and the bones. Accordingly, in the former the pain is rather seated in the muscles, spreads according to their course, and is more changeable in respect to place; in the latter, the pains are in the joints and along the bones. Rheumatism is not accompanied with those earthy tumours and accumulations which characterise the gout. In the latter disease, the sweat sometimes leaves a fine earthy dust upon the skin of the patient. Both diseases may, however, be present in the body at the same time, and be combined with each other. Rheumatism may also change, with time, into the gout, if, with the advancing age, the disease passes from the muscular system to the bones and joints. If nature is no longer vigorous enough to form a regular eruption of the gout—if the individual is old, or the disease is checked in its course, it often attacks the internal parts, the stomach, the lungs, the brain, and may thus prove fatal.

Respecting the treatment of gout, the diet which is to be observed, &c., many erroneous opinions still prevail. Some believe that, particularly in the podagra, no remedy ought to be taken; others trust entirely to purgatives; others seek a remedy in abstinence and drinking water; others, misled by the theory of Brown, who placed the podagra entirely in the class of asthenic diseases, seek for a remedy in strong liquors. There is, however, no specific against gout. The treatment of the disease must be regulated by the judgment of a cautious physician, who carefully observes the age and the bodily constitution of the patient, his habits, the condition of the vital powers, the state of his arterial system, and the peculiar nature of the case. With one arthritic patient, for instance, bleeding, drinking of water, and the use of cooling means, may be very necessary, which with another may become injurious, nay, fatal; as may be the case, on the other hand, with exciting, diaphoretic, and other means.

GOVERNOR; a contrivance for equalising the motion of mills and machinery. When any part of the machinery of a mill is suddenly stopped, or suddenly set a-going, and the moving power remains the same, an alteration in the velocity of the mill will take place; and it will move faster or slower. Every machine having a certain velocity at which it will work to more advantage than at any other, the change of velocity arising from the foregoing cause is in all cases a disadvantage, and in delicate operations exceedingly hurtful. In a cotton-mill, for instance, which is calculated to move the spindles at a certain rate, if from any cause the velocity is increased, a loss of work immediately takes place, and an increase of waste from the breaking of threads, &c.; on the other hand, there must be an evident loss from the machinery moving slower than is necessary. Various contrivances are used for remedying this evil. (See STEAM-ENGINE.)

GRAIN; the name of a small weight, the 20th part of a scruple in apothecaries' weight, and the 24th of a pennyweight Troy.

GRAMME; the unit of weight in France, which has taken the place of the *gros;* equal to 15.4441 grains Troy, or 5.6481 drams avoirdupois. All greater or less weights are formed from it by multiplication or division: for instance, the *decagramme*, a weight of 10 *grammes*, which is equal to 6 drams, 10.44 grains; the *hectogramme*, a weight of 100 *grammes* (3 oz. 4 dr. 8 gr.); the *kilogramme*, a weight of 1000 *grammes* (about 2 lbs. 8 oz.); the *myriagramme*, a weight of 10,000 *grammes* (about 26 lbs. 9 oz.). The *decigramme* is $\frac{1}{10}$th of a *gramme*, or 1 gr. $\frac{54}{100}$ths; the *centigramme* is a $\frac{1}{100}$th of a *gramme*, or .154 of a grain; the *millegramme* is $\frac{1}{1000}$th part of a *gramme*, or .0154 of a grain: it supplies the place of the *carat*.

GRANULATION, in *surgery*. The little, grain-like, fleshy bodies, which form on the surfaces of ulcers and suppurating wounds, and serve both for filling up the cavities and bringing nearer together and uniting their sides, are called *granulations*. Nature is active in bringing parts whose disposition, action, and structure have been altered by accident or disease, as nearly as possible to their original state; and, after having, in her operations for this purpose, formed pus, she immediately sets about forming a new matter upon surfaces in which there has been a breach of continuity. This process has received the name of *granulating* or *incarnation*. The colour of healthy granulations is a deep florid red. When livid, they are unhealthy, and have only a languid circulation. Healthy granulations on an exposed or flat surface rise nearly even with the surface of the surrounding skin, and often a little higher; but when they exceed this, and assume a glowing appearance, they are unhealthy, soft, spongy, and without any disposition to form skin. Healthy granulations are always prone to unite.

GRAPE-SHOT is a combination of small shot, put into a thick canvass bag, and corded strongly together, so as to form a kind of cylinder, the diameter of which is equal to that of the ball adapted to the cannon. The number of shot in grape varies according to the service or size of the guns.

GRAPHITE. See PLUMBAGO.

GRAPNEL, or GRAPLING; a sort of small anchor, fitted with four or five flukes or claws, and commonly used to fasten boats or other small vessels.

GRATE; a frame of iron bars, used for burning coal as fuel. Grates are commonly smaller than fireplaces intended for the consumption of wood, on account of the greater heat emitted by coal. Those used for burning anthracite should be made deeper and of a greater height than others, so as to present a comparatively small surface to the air; for, in very cold weather, the air conducts the heat from the surface faster than combustion renews it, so that, if the amount of surface exposed be large, the fire will go out. This kind of coal yields no visible smoke. The chimney, however, should be large enough to transmit smoke, otherwise some of the carbonic acid, which is formed during the combustion, will be sent into the room.—This gas is the suffocating vapour of burning charcoal.

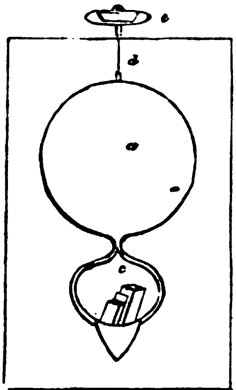
GRATINGS, in *ship-building;* a sort of open cover for the hatches, resembling lattice-work, serving to give light to the lower apartments, and to permit a circulation of air, both of which are particularly necessary, when, from the turbulence of the sea, the ports between decks are obliged to be shut.

GRAVE, in *music*, is applied to a sound which is of a low or deep tone. The thicker the cord or string, the more grave is the note or tone; and the smaller, the more acute. *Grave*, in the Italian music, denotes a very grave and slow motion, somewhat faster than *adagio*, and slower than *largo*.

GRAVER. See ENGRAVING.

GRAVIMETER. This is a very valuable instrument for determining the specific gravity of bodies. The

one represented beneath was invented by Nicholson. *a* is a hollow ball of brass or copper; *e* is a dish affixed to the ball by a short slender stem *d*; *c* is another dish affixed to the opposite side of the ball by a kind of stirrup. In the instrument actually made, the stem *c*, is of hardened steel, $\frac{1}{40}$ of an inch in diameter, and the dish *c* is so heavy as in all cases to keep the stem vertical, when the instrument is made to float in any liquid. The parts are so adjusted that the addition of 1000 grains, in the upper dish *e*, will just sink it in distilled water, at the temperature of 60° of Fahrenheit's thermometer, so that the surface shall intersect the middle of the stem *d*. Let it now be required to find the specific gravity of any fluid. Immerse the instrument therein, and by placing weights in the dish *e* cause it to float, so that the middle of the stem *d* shall be cut by the surface of the fluid. Then, as the known weight of the instrument added to 1000 grains is to the same known weight added to the weights used in producing the last equilibrium, so is the weight of a quantity of distilled water displaced by the floating instrument to the weight of an equal bulk of the fluid under consideration. And these weights give the ratio of the specific gravities. Again, let it be required to find the specific gravity of a solid body less than 1000 grains. Place the instrument in distilled water, and put the body in the dish *e*. Make the adjustment of sinking the instrument to the middle of the stem, by adding weights in the same dish. Take those weights from 1000 grains, and the remainder will be the weight of the body. Place now the body in the lower dish *c*, and add more weight in the upper dish *e*, till the adjustment is again obtained. The weight last added will be the loss the solid sustains by immersion, and is the weight of an equal bulk of water. Consequently the specific gravity of the solid, compared with water, is as its weight to the loss it sustains by immersion.



GRAVITY, in *physics*; the natural tendency or inclination of bodies towards a centre.

Terrestrial gravity is that force by which all bodies are continually urged towards the centre of the earth. It is in consequence of this force that bodies are accelerated in their fall, and, when at rest, that they press the body, or that part of the body, by which they are supported. As to the cause of gravity, or its nature, nothing is known; and it would be useless to detail the hypotheses advanced to account for this most important law of nature. All that can be said is, that it appears to be an essential property of matter, or, at least, of all matter that has hitherto become the object of human investigation, though it is by no means certain that matter may not exist which is not subject to its influence. This part of the subject appears to be beyond human comprehension. Instead, therefore, of wasting our time in useless speculation as to the cause, let us only attend to its effects, and content ourselves with examining more particularly the manner in which this principle operates on material bodies, and the laws by which it appears to be regulated; the principal of which, as deduced from experiment, or from the most unequivocal inferences, are as follows: 1. that gravitation takes place between the most minute particles of bodies; 2. that it is proportional to the masses of these bodies; 3. that it varies inversely as the square of the distance, in proceeding from the surface of the body outwards, or from its centre; 4. that it varies directly as the distance, in descending from the surface to the centre in uniform spherical bodies; 5, that it acts equally on bodies in a state of rest as on those in motion, and that its action in the latter case is always the same, whether that motion be to or from the centre of attraction, or in any other direction; 6. that it is transmitted instantaneously from one body to another.

Gravity, as relating to the science of mechanics, is divided into *absolute* and *relative*.

Absolute gravity is that by which a body descends freely and perpendicularly in a vacuum or non-resisting medium. *Relative gravity* is that by which a body descends, when the absolute gravity is constantly counteracted by a uniform, but inferior force, such as in the descent of bodies down inclined planes, or in resisting mediums. (See HYDROSTATICS, SPECIFIC GRAVITIES, and MECHANICS.)

GRENADE; a hollow sphere of iron, differing from a bomb by the smallness of its diameter. The smallest grenades, or those thrown by the hand, are called *hand-grenades*; they are from 2½ to 3½ inches in diameter. The fusee is calculated to burn from twelve to fifteen seconds, so that time is allowed for throwing them. The short distance to which they can be thrown, and the danger of accidents, have occasioned them to be disused. The small grenades are now employed only for what are called, in French, *perdreaux*, several of them being fastened to a board, and thrown from mortars. The grenades in general use are thrown from howitzers, and are of very different sizes, from two to twenty pounds' weight. They are chiefly calculated to act against cavalry and distant columns, where they may do great harm. In the battle of Wagram, one grenade killed and wounded forty men. As the utility of large grenades at sea is acknowledged, but objections exist to the use of howitzers of large calibre, the United States introduced the use of oval grenades in 1815, which may be fired from twelve and twenty-four pounders. In the British service the grenades are made with a spiral thread on the surface, that the opposition of the air may give them a rotatory motion, and thus more certainty of direction. Grenades are often thrown from cannons. During the siege of Gibraltar, they were thrown 3000 yards upon the Spanish works.

GRENADIER; originally a soldier destined to throw the hand-grenades. Soldiers of long service and acknowledged bravery were selected for this service, so that they soon formed a kind of *élite*. They were the first in the assaults. When hand-grenades went out of use, the name *grenadier* was preserved, and the troops so called generally formed one company of a regiment, distinguished by the height of the men and a particular dress, as, for instance, the high bear-skin cap. This continues to be the case in most armies. In the Russian and Prussian armies, the grenadiers form whole regiments belonging to *corps d'armée* of the guards. With the French, the grenadier com-

pany is (and was under Napoleon) the first of each battalion. The dragoons among them also had grenadier companies, which were afterwards united under the name of *grenadiers à cheval*, a kind of cavalry between cuirassiers and dragoons. Our own grenadiers have generally been found the most effective men in the service.

Groin, among builders, is the angular curve made by the intersection of two semi-cylinders or arches, and is either regular or irregular:—*regular*, as when the intersecting arches, whether semi-circular or semi-elliptical, are of the same diameters and heights; and *irregular*, when one of the arches is semi-circular, and the other semi-elliptical.

Groschen; a silver coin, so called from the Latin *grossus* (thick); thick coins, in opposition to thin lead coins. The oldest groschen known were struck in Treves, in 1104. The first Bohemian groschen were coined in 1296, at Kuttenburg. In 1525, the groschen was divided into twelve pfennige. In 1504, the small groschen, now in use, were first struck at the city of Gosslar. The Marien-groschen are valued at eight pfennige, and thirty modern groschen of Prussia are equal to a thaler.

Grosch is also the name of a Russian copper coin, worth two copecks.

Gross, in opposition to *net*, is applied to merchandise including that in which it is packed. It refers particularly to weight. Thus we say, "The bag of coffee weighs nine hundred weight *gross*," that is, including the weight of the bag.

Grotesque, in *painting*, is often confounded with *arabesque*. All ornaments compounded in a fantastical manner, of men, beasts, flowers, plants, &c., are called sometimes *arabesques*, and sometimes *grotesques*: but there is a distinction between them. Arabesques are flower-pieces, consisting of all kinds of leaves and flowers, real or imaginary. They are so called from the Arabians, who first used them, because they were not permitted to copy beasts and men. As they were also used by the Moors, they are sometimes called *moresques*. The Romans ornamented their saloons with paintings in which flowers, genii, men and beasts, buildings, &c., are mingled together according to the fancy of the artist. These ornaments are properly called *grotesques*, because they were found in the ruined buildings of the ancient Romans, and in subterranean chambers, which the Italians call *grottoes*.

The origin of these fantastic compositions is traced, by Bottiger, to the carpets of Persia and India, adorned with all the wonders of Oriental fable. In the baths of Titus and Livia, at Rome, in Adrian's villa at Tivoli, in the houses in Herculaneum and Pompeii, and many other places, such grotesques have been found; sometimes, indeed, showing an excess of ornament, but generally valuable for their arrangement and execution. Raphael was well aware of their beauty, and caused his pupils, particularly Giov. Nanni da Udine, to use them as patterns in painting the porticoes of the Vatican. He likewise used them, as the ancients did, for borders. The taste for grotesques has, in part, degenerated into the monstrous and unnatural; *grotesque* has therefore become a term of art to express a distorted figure, a strange monster, the offspring of an unrestrained imagination.

Grotto; a small artificial edifice made in a garden, in imitation of a natural grotto. The outsides of these grottoes are usually adorned with rustic architecture, and their inside with shell-work, coral, &c.

Grouping, in the *fine arts*, is that arrangement of objects by which their individual characteristics are severally resolved into the component parts of a whole, which is then called a group. A group may consist of as many parts or objects as the skill of the artist enables him to combine together, but cannot be formed with less than two. One object can never bear the name of a group; and even though there should be many objects introduced, unless they mutually assist each other in forming something more complete than either of them when separate and alone, they cannot be termed a group, for it is the essential principle of a group, that the parts should be so intimately combined and blended together, that they should lose their character as distinct objects and become an unalienable portion of a mass which should appear to be one—an undivided, indivisible whole. The parts should bear such a relation to each other, that if ever separated, as is the case sometimes in sculpture, they should lose much of their character, and should evidently show that they are but part of a group, and not complete in themselves.

Grouping is the first requisite of any work of art in which more objects than one are introduced, and may be divided into two classes, close and open, the former applicable to both masses and lines, the latter to lines only; or, to speak less technically, the close group may be formed of objects, some of which shall be broad and occupying a large space, as drapery, and others of a more slender nature, such as naked limbs, staves, &c.; in this case the character of the group will depend principally on the relation of quantities, but the direction of lines in such objects as naked limbs are still available materially to increase the effect, and the most perfect group must necessarily be of this class. The open group is rather tolerated as a skilful evitation of disadvantages, by a harmonious arrangement of slender objects, than held up to admiration for its intrinsic beauty. This species of group is by far the most difficult to achieve successfully, from the want of variety in the quantities; and its character will principally depend on the direction of the lines formed by the main objects. Lightness is generally the advantage proposed by this style of grouping, but disunion is too often the result; and it never can equal a skilful arrangement of lines, threading and overlaying well varied and properly combined masses.

From the above it would appear that, as grouping is dependent upon the relation of quantities and lines, it must be subject to mathematical rules, though they have never been strictly defined. What is termed the science of grouping, or composition, comprises merely a few vague and general principles, gleaned from the works of those who have been great in practice and experience. These differ in painting and sculpture, what is deemed right in the one being rejected in the other. From the different nature of the materials employed, and the different process of working them, inductions of principles widely differing have resulted. The pyramidal form of groups is, in sculpture, almost a matter of necessity, from the solidity required in the base to support the weight of the upper part. Unless worked in metal, lightness of composition is nearly proscribed to this branch of the arts. The example we have chosen of a group from the antique sculpture, the Toro Farnese (see Arts, Fine, *Plate* V.), is carried as far in the way of

lightness as the art will allow in so extensive a composition; but it will be seen that, to support the superincumbent weight, blocks or stems of trees have been introduced, which can be looked upon as no other than unavoidable defects. Many attempts have been made to avoid the use of these incumbrances; but we are not aware of any instance in which it has been so successfully done as in the noble group of the Archangel Michael and Satan, by our own Flaxman, in the possession of the Earl of Egremont, to which we shall presently have occasion again to refer on another ground. In this instance, the tail of Satan is so admirably entwined with the legs of the angel as to afford all the requisite support for the upper part of the figure, whilst it conceals nothing in the principal view of the group.

In sculpture, a group requires to be so composed as to display a harmonious arrangement of lines, and a due balance of masses, from more points of view than one—frequently from all points, which compels a more purely scientific arrangement than is absolutely necessary, and we may say usually adopted, in the sister art, which professes to afford but one point of view; and it may probably be concluded that the absence of due investigation on the part of the most numerous class of professors, those of painting, has left us decidedly without true principles either of grouping or judging of groups when executed. The sculptor, from the nature of his materials, can achieve all that is required of him by positive experiment. Experience, therefore, supplies the want of science with him, and man is apt to be too indolent to search for a principle to supply what he can with facility obtain by practice. The painter, on the other hand, has not such ready means of experiment; to alter is with him to re-execute: but he has an all-powerful veil in chiaro-scuro to hide the errors he was not sufficiently skilful or industrious to avoid. Most of the artists have a kind of bed of Procrustes to which they reduce all their subjects; and by the application of the few vague rules, gathered from the practice of their predecessors, whom they strictly imitate, they produce what, with the aid of colour and chiaro-scuro, pass current for scientific works, from the want of some true standard or principle to judge by.

The few principles established may be comprised within the following rules:—

1. The principal objects should occupy the largest spaces, and form the largest masses of the group, and should be set off and contrasted by smaller parts of different character.

2. The two sides should be varied both in quantity and character.

3. The general form or outline of the group should be free from harsh, angular projections, or vacuities of any decided shape, and the ground-plan as varied as the nature of the objects will allow.

These rules, amplified with such necessary consequences as setting off projecting parts with receding ones, convex forms with concave or flat, upright with diagonal or horizontal, straight with curved lines, are all that are at present agreed upon. The arts have progressed rather by strong feeling or genius than any decided principle, which at once explains the inequality found in the works of all the great masters, and the utter incapability of their pupils to preserve the acquirements of what is from hence evidently falsely termed science. Frequently the eye has acquired correctness and taste, and the hand great facility; but the exercise of the mind has had so little to do with it that though the artist could perceive errors, and point out their remedy, he was unable to explain the principle on which his decision was formed.

The pyramidal form is one of the most approved for the general shape of a group, as conventionally settled to be the most universally agreeable, and, perhaps we may add, to the artist most useful, most easily managed, and, under any circumstances, most readily come at. But, unless to produce a peculiar effect, which will be treated of under the head of ILLUSTRATION, it will be the better if the apex of the pyramid be removed a space from the centre, for the sake of obtaining more variety and inequality in the two sides. The principal differences in groups will be found to exist in the ground-plans, on which various theories have been adopted. Raffaelle has given us a specimen of an oval or circular arrangement of figures in his cartoon of the Death of Ananias. Titian took a bunch of grapes for his system, which gave a central convexity with retreating ends. Others have adopted the opposite scheme, making their groups on a concave ground-plan. But these are incidental applications of the foregoing rules to particular cases, and perhaps too evidently systematic to bear much repetition. One of the most powerful engines in grouping is the arrangement of the lines formed by the objects, so as to secure a sweep or convolution, as the group is intended to be of a graceful or an energetic character.

Long and flowing lines have always an agreeable effect in a composition of numerous parts, as they give the appearance of connection and union, which we have already shown to be the essential principle of grouping. Some remarkable effects may be found produced by this means, of which one of the most striking instances exists in Fuseli's stupendous Lazar House. The long line formed by the principal figure, with his drapery blended into that of the female about his knees, is carried on to the other figures behind so judiciously, that it would be impossible to detach any portion, however slight, without breaking a link of the mighty chain with which those horrors are bound together. Another instance, of a more graceful and agreeable character, will be found in the Paolo and Francesca, in the Whirlwind, from Dante, by the same artist. Here the flowing lines of two exquisitely drawn figures are so intimately and beautifully blended, so naturally and yet so ingeniously lengthened, by making one figure considerably higher than the other, that, as a composition of two figures, it is perhaps without its equal in the world. The same principle pervades Flaxman's celebrated group of the Archangel Michael and Satan. Being in sculpture, and to be viewed from different points, it was constructed, almost of necessity, with a view to agreeable variety and play of line alone. In it you have a long flowing line, twisted into a kind of knot at the base, in the figure of Satan, and thereby affording a solidity which supports, and at the same time contrasts, the lightness and tenuity of the angel above. But there would be no end to instances of the application of the rules already laid down: all the finest works of art are constructed according to them, with variations in manner and style, which form the peculiarities, merits or demerits, distinguishing each school.

It is advisable to avoid too sudden and violent contrasts near the principal figure or object, if there be more than two components to the group. A kind of echo of the actions has sometimes a beautiful effect, as giving strength and preponderance to what is intended to be a leading feature; but these delicacies in grouping require considerable practice, before success can be ensured. Some remarkable instances of unity have been produced by these means, but more frequently sameness and want of variety are the result. In the Witches, from Macbeth, poetical expression allows of great similarity, and the character of the objects almost preclude much difference of attitude: here the pyramid reigns in full force; and this is one of the instances in which the equality of the two sides might have been admitted; but, upon a principle belonging to *illustration* rather than grouping, Mr. Frank Howard has preferred an arrangement by which his "Weird Sisters" become an admirable specimen for the present subject, without being in any way deficient in poetical character. To obtain originality, he has made one of the side figures principal, and occupying the largest space, and contrasted the broad and simple folds of her drapery by the narrow and diverging folds of the dress of the centre figure. The third assimilates to both her sisters, having some parts of her vestment in ample folds, and some more close and contracted. There is no violent contrast: the lines formed by the drapery and staves on which the witches rest, are gradually raised from each other, until the two sides are inclined in opposite directions; the group is solid; and the external form without decided angles or vacuities, will not bear the removal of a line. The similarity of the attitudes of the figures ensures that union which is the first requisite of a group.

We find few groups among the relics of antiquity, and those, with one or two exceptions, constructed on the most simple plan. But, celebrated as some of these are, they do not reach the perfection of the single figures. It must be allowed that, having little more than sculpture remaining, we have not so good an opportunity of judging as could be wished; but the fame of the most admired pictures has come down to us, and we do not find the Venus of Apelles, or that of Praxiteles, rivalled by a group. The most extensive and elaborate composition in sculpture which has been preserved is that already referred to as our exemplar (see ARTS, FINE, *plate* V.), the Toro Farnese, more remarkable as a scarce specimen, than for any particular merit as a group. The bull, from which it takes its name, occupies the apex of the pyramidal form to which it generally tends; and the avenging sons, Zethus and Amphion, one pushing and the other pulling the infuriated animal, are skilfully varied without any violent contrast, both aiding to complete the general form by leaning forward. But from hence the skill declines. Dirce, seated upon the rock on which Zethus, Amphion, and the bull are standing, seems rather in the character of a support to the animal than a principal of the composition. Antiope, in a quiet attitude on the other side, fills up an unpleasant opening between the bull and one of her sons, and serves by her calmness to give vigour to the group, but to which, strictly speaking, she can hardly be said to belong. The unfortunate Lycus is likewise detached, and serves to ornament the rocky base as an adjunct rather than a component part of the group. Altogether, it does not display science in arrangement commensurate with the exquisite execution of individual parts, for which the antique sculpture is so remarkable, and in which we are taught to consider the remains unrivalled at present, and impossible to be surpassed at any time. The ancients do not seem to have held grouping in equal esteem with individual character of form and fine proportion. This love of simplicity, in opposition to complexity and combination, is also apparent in another art, that of music, in which their prejudices were so strong as to induce the memorable infliction of punishment for adding a few notes to their scale, and affording greater capabilities for the display of any power they might possess: an act more worthy of nations deemed by them barbarians. But the same feeling predominating in all the relics of their works of art, whether of painting or sculpture, we are compelled to search for its actuating principle in want of skill to combine, or appreciation to admire the combination of beauties of different characters.

The earliest grouping of any extent is to be found in the works of the Florentine school: the Campo Santo of Pisa, and the gates of Ghiberti, so admired by Michael Angelo, who afterwards carried grouping to a perfection that has never yet been excelled. And, if the ancients are alone in the representation of single and simple figures, Michael Angelo must be considered alone in the combination of extensive and energetic groups.

Grouping has, since his time, been an object of unceasing study, and is now considered one of the most essential requisites in a work of art, and one of the highest objects of attainment. Still the science has been neglected for practical facility, and we cannot but think that the arts decline in consequence. One great mind arises, and from an intuitive perception of the relations of quantities and lines, or from some strong impression produced by accidental circumstances, originates a splendid work, of a different character from any of his predecessors. If really scientifically constructed, it seldom happens that the artist is able or willing to explain the principles on which he acted; his pupils, therefore, merely imbibe some portion of their master's feeling, and, parrot-like, imitate his style, which soon degenerates into mannerism, because attempted without a knowledge of the originating principle, and without the same perception of the qualities of mass and line.

The fewer the objects the more difficult to group, which gave Fuselli occasion to say that "to invent a good single figure was a very difficult thing, that to compose two was not very easy, but that three figures would compose themselves." The slightest attention to diversifying the quantities and lines of two figures on either side of a third in the centre, so completely ensures an agreeable general form, and a due balance of parts, as almost to justify this quaint remark. Thus, in the celebrated group of Laöcoon and his two sons, the attitudes of the latter are combined with that of the principal figure, so as to produce a pyramidal form, varied on each side in shape and quantity; and the vacuities formed by the extended action of the father are filled up, by the limbs of the sons, in such a simple and natural manner as to appear almost the necessary consequence of the materials. But suppose the abstraction of one of the children, and the difficulties of the grouping are immensely increased. Had the remaining child been on either side, the due balance of parts could hardly have been

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preserved The disproportion of size between the figures would have created too great a contrast to allow of harmony, and the preponderance of the one side would have given a tottering character to the group, that would have excited an apprehension of more danger to the son from the overwhelming weight of his father than from the bite of the serpent.

Mr. Ottley remarks that the Florentine and Roman schools arranged their groups of figures so as to make complete compositions without the intervention of drapery, and that they clothed their figures in such a manner as not to interfere with the first arrangement; but, in the schools which followed, the drapery became an essential part of the composition, which style prevails strongly in the present day, having derived a charm from being peculiarly adapted to splendour of colour and chiaro-scuro.

GUIDES; in some armies, persons particularly acquainted with the ground, who serve in the staff, to give the necessary information, and point out the best route for an army. As it is, however, impossible always to have officers of this kind, some armies have geographical engineers attached to the staff, whose particular studies are geography and topography. Napoleon gave the name of *guides* to his first body of guards, formed after he had been on the point of being surprised and taken prisoner in a castle on the Mincio.

GUILD, in *commerce;* a society, fraternity, or company, associated for carrying on commerce or some particular trade. The merchant guilds of our ancestors answer to our modern corporations. The societies of tradesmen, exclusively authorized to practise their art, and governed by the laws of their constitution, played a very important part in the middle ages. Few institutions show the progress of civilization in a stronger light than that of guilds, from the first rude mixture of all kinds of labour, its division, the establishment of corporations, the corruption of these by privileges which are in some cases highly absurd, down to their total abolition, and the restoration of liberty to human industry. Though the division of labour is comparatively of recent date, yet the division of the people by occupations is one of the oldest and rudest political institutions of which history makes mention. These divisions by occupations or castes generally took their rise, however, from a difference of national origin, as with the Egyptians, Indians, &c. The Romans had various mechanical fraternities, which might be compared to modern guilds, as they had the right to enact by-laws. In the later times of the republic, these societies not unfrequently appeared as political parties; and, on this account, their influence was restrained, and they were partly abolished after the establishment of the monarchy. In Italy, the cradle of the class of free citizens in the middle ages, and particularly in the Lombard cities, those connecting links between the ancient and modern civilization, some remains of these Roman institutions, or recollections of them, probably contributed to revive the guilds, which naturally presented themselves as an excellent means of supporting the citizens against the nobility, by uniting them into powerful bodies.

With the increasing importance of the cities, which became the seats of industry, and with the establishment of their constitutions, begins also the extension of guilds. The chief reason that mechanical industry was freely developed in the middle ages, at the same time with agricultural, which had been exclusively cultivated by the Greeks and Romans, was the independence which the mechanics acquired with the growth of municipal and civil liberty. Mechanical industry has always been essentially of a democratic character, and would never have flourished under the feudal system. It is not possible now to give the exact date of the origin of these societies in Upper Italy. Traces of them are found in the 10th century. Thus, in Milan, we find the mechanics united under the name *credentia*. It is certain that small societies of mechanics existed as early as the 12th century, which appear, in the following century to have been in the possession of important political privileges. We even meet with abuses in these bodies as early as this period; and, several centuries later, the guilds became the subject of bitter and just complaint, particularly those in Germany.

When the advantages of these associations became known and felt, they rapidly increased; and, in the struggles of the citizens and the nobility, the principal resistance against the latter was made by the corporations. As soon as the citizens acquired an influence on the administration, the guilds became the basis of the municipal constitutions, and every one who wished to participate in the municipal government was obliged to become the member of a guild. Hence we often find distinguished people belonging to a class of mechanics, of whose occupation they probably did not know any thing. This mixture of social and political character, as well as the insignificance of the individual, considered merely as such, is a natural consequence of the rudeness of the period. Just principles are the work of time. It is only by slow degrees that the true is separated from the false, the essential from the unessential. Political, like religious and scientific principles, are at first always vague and incoherent. Men must have long experience of the concrete before they form just notions of the abstract. Thus it is a characteristic of the middle ages, that political rights were considered as arising from special privileges. All that men enjoyed was looked upon as a gift from the lord paramount. In fact, the idea of the rights of man, as an individual, has been developed only in very recent times. Even the ancient republics had no just conception of it.

In Germany, the establishment of guilds was also intimately connected with that of the constitutions of the cities. The latter were different according as the ancient Roman or the old German organization of the community prevailed; the relations among the mechanics were also very different. The mechanical arts were at first practised chiefly by the villeins; and, even in the time of Charlemagne, they appear to have been pursued on the estates of the feudal lords, by the bondsmen, as is still the case on the great possessions of Russian noblemen. Commerce on any very extended scale could not, however, be carried on by bondsmen. Although there early existed free mechanics, yet they were also under the protection and jurisdiction of the feudal lord, before the privileges of the cities were acknowledged, except in cities of Roman origin. These privileges early secured to them, as a distinct class of vassals, a sort of organization under the direction of the masters of each trade, as appears from the oldest law of the city of Strasburg, which seems to belong to the 15th

century; and out of this the guilds in Germany may have originated. The full developement of the guilds in Germany occurred in the last half of the 12th century, and the oldest examples are those of the cloth-shearers and retailers in Hamburg (1152), the drapers (1153) and shoemakers in Magdeburg (1157). But they possessed no political importance in Germany before the 13th century, when a struggle arose between them (the labouring classes) and the citizens belonging to ancient families, the civic aristocracy. The guilds were victorious, and became so powerful, that even persons of "free occupations" joined these associations, as the allodial possessors of land sometimes placed themselves under feudal lords. The corporations of merchants and mechanics became more and more confirmed in their privileges and monopolies, whilst the country people suffered by being made, in many respects, the slaves of the guilds. Particular branches of industry were often subject to restrictions in favour of the guilds, which were sometimes of a most offensive nature. The guilds became insupportable aristocracies, sometimes allowing only a certain number of master mechanics in the place, and seldom admitting any one into their associations except favourites of the masters. The examinations for the admission of a journeyman to the rank of a master were used as means of extorting money, and were often combined with the most absurd humiliations.

The guilds are now abolished in a considerable portion of Germany; and yet many persons wish to restore the ancient order of things, as a support of aristocratical distinctions, and as tending to repress that free exercise of industry which is so favourable to the growth of the democratic spirit. Attempts were made to check the insolence of the guilds by the laws of the empire, in 1731, but without success. In France, the guilds also originated with the increasing importance of cities, and became general in the reign of Louis IX.; but they were subject to abuses, as in Germany, and were abolished at the time of the revolution. In this country, the societies of mechanics are important principally in a political respect, on account of their connection with the democratic element of our constitution.

GUILLOTINE. This instrument has been erroneously considered the invention of Guillotin, a physician of Paris, during the French revolution. A similar instrument, called *mannaia*, was used in Italy for beheading criminals of noble birth. The *maiden*, formerly used in Scotland, was also constructed on the same principle. The Convention having determined, on the proposition of Guillotin, to substitute decapitation for hanging, as being less ignominious for the family of the person executed, the guillotine was adopted, also on his proposition, as being the least painful mode of inflicting the punishment. It was erected in the *Place de Grève*, and the first criminal suffered by it April 25, 1792. Portable guillotines, made of iron, were afterwards constructed. They were carried from place to place, for the purpose of executing legislative enactments. This machine consists of two upright pillars, in the grooves of which a mass of iron, sharpened at the lower extremity, is made to move by cords. Being raised to a certain height, it falls, and at once severs the head of the criminal (who is laid upon a horizontal scaffolding) from his body. It is much surer than the sword or axe, which is sometimes used for decapitation, and of which we read, in many instances, that several blows have been necessary to put an end to the life of the sufferer. In the reign of terror, it was called by the most violent political fanatics *notre très Sainte-Guillotine*. It is still the common instrument of capital punishment in France.

GUINEA; an English gold coin, legally worth twenty-one shillings sterling. Guineas were first coined in the reign of Charles II. (1662), of gold which the English procured from Guinea, and hence the name. Till 1718, they were of the value of twenty shillings sterling.

GUINEA CLOTH. Mariners give the name of Guinea to a much greater extent of the African coast than is recognized by geography; and, in commerce, several articles made for the African trade are called by this name. Guinea cloth is a kind of calico, calculated for the African market, where it is an important article of barter. There are also Guinea knives, &c.

GUM; one of the proximate principles of vegetables, distinguished by the following properties:—It is an insipid, inodorous, uncrystallizable solid, more or less transparent, the various colours which the different kinds possess being derived from mixture with colouring principles, while exuding in a fluid state. It is insoluble in alcohol, and extremely soluble in water, in which properties it is the reverse of resin. It differs from mucilage only in being deprived of the water which rendered it fluid; and, of course, when water is added, it again becomes mucilage. This mucilage is apparently not susceptible of fermentation, and may be kept for a long time, as it is less disposed to spontaneous changes than almost any vegetable product. Its chemical composition so nearly approaches sugar, that it may be converted into it by means of nitric acid. Gum, as above defined, is identical in all vegetables, and the different kinds vary only in the quantity and quality of the substances united with them. It exists naturally almost pure in gum-Arabic and gum-Senegal, and, more or less mixed, in the gum which exudes from the plum, cherry, and other fruit-trees, as also in the mucilage of flax-seed, slippery elm, &c. Various resins and gum-resins are commonly confounded under this appellation.

GUM-ARABIC is the product of the *mimosa nilotica* and some other species of the same genus, inhabiting the sandy parts of Arabia, Egypt, Senegal, and Central Africa. It exudes spontaneously, in a fluid state, and remains attached to the branches after it has concreted and become solid. This exudation takes place continually, during the whole of the dry season, from October to June, but more copiously immediately after the rains. December and March are the two months in which this gum is collected by the Arabs, with whom it is an important aliment, those tribes that are continually wandering in the desert often making it their principal article of food during a great part of the year.

Gum-Arabic is obtained in rounded masses, transparent, or of a light yellow colour, capable of being easily reduced to a powder, insipid to the taste, or possessing a slight acidity, which, however, is perceptible only by those who use it habitually. It is easily soluble in water, and the solution has the property of conveying pulverised solids through a filter, which would separate them were they suspended merely in water: thus it is impossible, by

this means, to separate powdered charcoal from gum-water. In pharmacy, gum-Arabic is employed to suspend in water substances which otherwise could not be kept equally diffused, as balsams, fixed oils, resins, &c.; but its principal consumption is in manufactures, forming the basis of crayons and cakes of water-colours, as well as of writing-ink, and several liquid colours, serving to increase the consistency of these colours, and to prevent their spreading in calico-printing, affording a clear cement for joining light substances, which may be prepared in a moment, giving a lustre to ribands, silks, &c., which, however, is destroyed by the application of water. It is, besides, used for a great variety of purposes. In medicine, it is frequently employed, especially in dysenteries, as a demulcent, and enters into the composition of a variety of emollient preparations. Gum-Senegal, as it is called, has the same chemical character with gum-Arabic: indeed, the chief part of the gum-Arabic of commerce is brought from Senegal, and constitutes the most important article of trade with that country.

Gum Resins apparently combine the properties of gums and resins, being partly soluble in water, partly in alcohol; but they are evidently compound substances, formed of two or more vegetable principles, which, indeed, are often in a state of mere mechanical mixture. Aloes, assafœtida, galbanum, gamboge, olibanum, scammony, and a great variety of concrete juices, are referred to this head. (See Resin.)

Gun; a fire-arm, or weapon of offence, which forcibly discharges a ball, shot, or other offensive matter, through a cylindrical barrel, by means of gunpowder. *Gun* is a general name, under which are included divers, or even most species of fire-arms. They may be divided into great and small. Great guns, called also by the general name *cannons*, make what we also call *ordnance*, or *artillery*, under which come the several sorts of cannon. Great guns of all sorts, cannons, carronades, &c., whether of iron or brass, are cast in sand, and afterwards bored. Small guns, muskets, fowling-pieces, &c., are forged from bars of malleable iron, hammered to a proper width, and then turned over a mandril, or cylindrical rod, so as to form a tube with a bore smaller than that of the intended piece. The edges overlap about half an inch, and are firmly welded together. The tube is then hammered, in semicircular grooves, on an anvil hollowed for the purpose. It is afterwards bored with several instruments, of different sizes, in succession, till the hollow is sufficiently large and smooth. A plug is firmly screwed into the breech, so as to make it perfectly close. The projecting parts of the barrel, the sight, the loops which fasten it to the stock, &c., are soldered on.

Gunnery signifies the science of using artillery against an enemy judiciously, and to the greatest effect. Besides an accurate acquaintance with the management of ordnance of all kinds, the military engineer should understand the range, the charge, and direction necessary for different distances, their materials, with the manner of making and of preserving them. He should also know the component parts, the fabrication, the effect of gunpowder, and the method of preserving it, with the manner of preparing and managing every thing that appertains to ammunition. The artillerist must be able to instruct his men in their exercises, both on horseback and on foot; he must be well acquainted with the management of the horses that are used to transport the cannon and to mount the flying artillery; he must know how to harness them to the cannon, how to move and manœuvre with them on ground of every kind, how to repair, at the moment, any sudden damage, and must be thoroughly acquainted with tactics, especially with the peculiarities of the ground, and with the art of availing himself of them most judiciously in the disposition of his artillery. He must, finally, be able to attack or defend any position; he must have an accurate acquaintance with the science of fortification; but especially he must be practically skilled in throwing up batteries and other field-works, so that he may be able, by disposing his artillery before or within a strong place, to assist the engineer most effectually in its attack or defence. Besides, the artillerist has often the regulation of the lights, and other signals, in time of war, of the fire-works in peace, &c. All this must be learned by experience, and by the study of auxiliary sciences. Mathematics (particularly the doctrine of curves, to calculate the path of the balls), physics, and chemistry, are also very necessary, in order to understand the effect of powder, and the manufacturing of ammunition, as well as that of all kinds of fire-works.

Gunpowder is a mixture of saltpetre, sulphur, and charcoal. If we may believe the relations of the missionaries, and the reports of the Chinese historians, the Chinese were first acquainted with the application of gunpowder. Perhaps it proceeded from them to the Arabs; for, in 1331, the Moors used it in their operations before Alicant, and certainly in 1342 at Algesiras. Among the Europeans, the traces of this invention are still more ancient; for the Greek fire, which was first employed in 668, must have, at least, contained saltpetre mixed with pitch, naphtha, &c., since it was customary, by means of it, to hurl stones from metallic tubes. The first information of the knowledge of the Europeans with regard to the chemical mixture of powder is found in the ninth century, in a book composed by Marcus Gracchus, preserved in the University of Oxford, which also accurately explains its composition. Roger Bacon (who died in 1294) was likewise acquainted with the power which saltpetre has, when set on fire, of burning vividly.

The discoverer of the power of powder, when confined and set on fire, of propelling heavy bodies, was, according to common report, Berthold Schwartz, a monk, who is said to have lived at Mayence, between 1290 and 1320. He, in some of his experiments in alchemy, had put the mixture into a mortar, and, having accidentally dropped into it a spark of fire, to his astonishment saw the pestle fly off into the air. In 1356, powder is mentioned in the accounts of the treasury of Nuremberg; in 1360 the House of Assembly at Lübeck was burned by the imprudence of the powder manufacturers; and, in 1365, the Margrave of Misnia had pieces of artillery in his possession. In the course of a few years afterwards, it was known through Europe. Thus the first traces of this invention would appear to be found in Germany; other nations, however, have put in their claims to this honour.

The proportion of the ingredients in the composition of gunpowder is different in different countries: in the Prussian powder-mills, 75 parts of saltpetre, 11 parts of sulphur, and 13½ parts of charcoal, are

used but in the French mills, 75 parts of saltpetre, 12½ of coal, and 12½ of sulphur. In the manufacture of this article, which is carried on in very different ways, much depends upon the goodness of the ingredients. The crude saltpetre is broken up, moistened, and exposed to the action of a slow fire, continually skimmed and violently agitated, till all the moisture evaporates, and the saltpetre remains in the form of a fine powder. The sulphur is pulverized after having been well purified. The charcoal is that derived from the alder, or any other soft wood or bushes, as, for example, hemp-stalks, which are burned with great care in a confined room, and reduced to a fine powder.

These three ingredients are moistened, and brought under a stamping, or more commonly a rolling-mill, where two metallic, or, which are better, marble cylinders, turn round a fixed vertical wooden pillar, and crush to pieces the mixture, which lies upon a round smooth surface of the same material. Other mills effect this bruising operation by several large iron runners, revolving upon a metallic plate, similar to a painter's grinding-stone, or by a rapid revolution of the mixture in casks containing metallic balls. After the mixture, in some one of these ways, has been acted on in the mills for the space of six or eight hours, and when the ingredients are united, and form one homogeneous mass, it is pressed, while yet wet, by means of cylindric rollers of wood, through a perforated sieve, by which the powder is formed into grains. In other mills, this process of forming it into grains takes place after the powder has been pressed between two boards into a solid cake, and then submitted twice to the operation of a grooved roller of wood or copper.

The powder, after it has been grained, is spread upon boards in the drying houses, and exposed to the strong heat of an oven for two days. In order to prevent its taking fire, the oven is well lined with clay and copper. Of late years, this process of drying has been generally effected by means of steam. Finally, the powder is sorted by being passed through several sieves. In the first, or coarsest, remains what is entirely useless; through the second passes the second-sized, or cannon powder; and through the third and last the finest, or musket powder. The powder, thus prepared, is packed in oaken casks.

Gunpowder should be of a slate colour, with a round and pure grain, and also have a uniform colour on being broken up; nor should it leave behind it, either on the hand or on paper, any black spots. When set on fire, it should burn at once, without crackling, or leaving upon paper any appearances of its combustion. When applied to the tongue, the taste should be extremely cooling. In order to prove its strength, let any person apply an accurately fitting ball to a small mortar, and the distance to which the ball is thrown will prove the strength of the powder. The French government *eprouvette* is a mortar seven French inches in diameter, and three ounces of powder must throw a copper globe, of 60 pounds weight, 300 feet; otherwise the powder is not admissible. Another method is, to suspend a small cannon as a pendulum, and to judge of the strength of the powder by the force of the recoil, which will describe a greater or less arc of a circle. In the preservation of powder, fire and water must both be carefully guarded against.

Powder destined for military purposes should be deposited in an airy building, removed at least 1000 paces from any habitation, provided with lightning rods, and surrounded with walls, ditches, and palisadoes; there should be a guard constantly set, to prevent the introduction of fire, and to hinder all persons from entering who have things about them that will produce fire. These buildings should contain openings for the free passage of the air; the casks should stand upon a platform of wood, at a distance from the wall, and the powder itself should be sunned and dried every one or two years. If the powder is to be kept in damp places, as, for example, in the casemates (arched passages under ground) of fortresses, the walls should be internally covered with lead, and a vessel filled with unslaked lime placed in the middle of the apartment, so that the moisture of the atmosphere may be attracted by the lime.

In the transportation of gunpowder, dust, which is liable to penetrate the cracks and joints of the casks, should be carefully guarded against, as the friction may produce explosion. It is also necessary for its good preservation, that the carriages and vessels in which it is transported should be water-tight. We may effectually preserve it from moisture, by dipping the cask and the sackcloth covering into melted pitch. Vessels prepared in this way, and containing powder, may be immersed in the water for weeks, without having their contents in the least injured. The effects of this substance, when set on fire, are truly wonderful. When powder is heaped up in the open air, and then inflamed, it detonates without report or effect. A small quantity of powder left free in a room, and fired, merely blows out the windows; but the same quantity, when confined in a bomb within the same chamber, and inflamed, tears in pieces and sets on fire the whole house. Count Rumford loaded a mortar with one-twentieth of an ounce of powder, and placed upon it a 24-pound cannon, weighing 8081 lbs.; he then closed up every opening as completely as possible, and fired the charge, which burst the mortar with a tremendous explosion, and raised up this immense weight.

GUNTER'S LINE; a logarithmic line, usually graduated upon scales, sectors, &c. It is called the *line of lines*, and *line of numbers*, being only the logarithms graduated upon a ruler, which therefore serves to solve problems instrumentally, in the same manner as logarithms do it arithmetically. It is usually divided into a hundred parts, every tenth of which is numbered, beginning with 1, and ending with 10, so that, if the first great division, marked 1, stand for one-tenth of any integer, the next division, marked 2, will stand for two-tenths, 3, three-tenths, and so on; and the intermediate division will, in like manner, represent one-hundredth parts of an integer. If each of the great divisions represent ten integers, then will the lesser divisions stand for integers; and if the great divisions be supposed each 100, the subdivisions will be each 10.

Use of Gunter's Line:—1. *To find the product of two numbers.* From 1 extend the compass to the multiplier; and the same extent, applied the same way from the multiplicand, will reach to the product. Thus, if the product of 4 by 8 be required, extend the compasses from 1 to 4, and that extent, laid from 8 the same way, will reach to 32, their product.

2. *To divide one number by another.* The extent

from the divisor to unity will reach from the dividend to the quotient; thus, to divide 36 by 4, extend the compasses from 4 to 1, and the same extent will reach from 36 to 9, the quotient sought.

3. *To find a fourth proportional to three given numbers.* Suppose the numbers 6, 8, 9: extend the compasses from 6 to 8; and this extent, laid from 9 the same way, will reach to 12, the fourth proportional required.

4. *To find a mean proportional between any two given numbers.* Suppose 8 and 32: extend the compasses from 8, in the left-hand part of the line, to 32 in the right; then bisecting this distance, its half will reach from 8 forward, or from 32 backward, to 16, the mean proportional sought.

5. *To extract the square root of a number.* Suppose 25: bisect the distance between 1 on the scale and the point representing 25; then half of this distance, set off from 1, will give the point representing the root 5. In the same manner, the cube root, or that of any higher power, may be found by dividing the distance on the line, between 1 and the given number, into as many equal parts as the index of the power expresses; then one of those parts, set from 1, will find the point representing the root required.

Gunter's Quadrant is a quadrant made of wood, brass, or some other substance, being a kind of stereographic projection on the plane of the equinoctial, the eye being supposed in one of the poles, so that the tropic, ecliptic, and horizon form the arches of circles; but the hour circles are other curves, drawn by means of several altitudes of the sun for some particular latitude every year. This instrument is used to find the hour of the day, the sun's azimuth, &c., and other common problems of the sphere or globe; as also to take the altitude of an object in degrees.

Gunter's Scale, usually called by seamen the *gunter*, is a large plain scale, having various lines upon it, of great use in working the cases or questions in navigation. This scale is usually two feet long, and about an inch and a half broad, with various lines upon it, both natural and logarithmic, relating to trigonometry, navigation, &c. On the one side are the natural lines, and on the other the artificial or logarithmic ones. The former side is first divided into inches and tenths, and numbered from 1 to 24 inches, running the whole length, near one edge. One half of the length of this side consists of two plane diagonal scales, for taking off dimensions for three places of figures. On the other half of this side are contained various lines relating to trigonometry, as performed by natural numbers, and marked thus, viz. *Rhumb*, the rhumbs or points of the compass; *Chord*, the line of chords; *Sine*, the line of sines; *Tang.*; the tangents; *S. T.*, the semi-tangents; and at the other end of this half are *Leag.*, leagues or equal parts; *Rhumb*, another line of rhumbs; *M. L.*, miles of longitude; *Chor.*, another line of chords. Also in the middle of this foot are *L.* and *P.*, two other lines of equal parts: and all these lines on this side of the scale serve for drawing or laying down the figures to the cases in trigonometry and navigation. On the other side of the scale are the following artificial or logarithmic lines, which serve for working or resolving those cases, viz. *S. R.*, the sine rhumbs; *T. R.*, the tangent rhumbs; *Numb.*, line of numbers; *Sine*, sines; *V. S.*, the versed sines; *Tang.*, the tangents; *Meri.*, meridional parts; *E. P.*, equal parts.

Gunwale, or Gunnel, of a Ship, is that piece of timber which reaches, on either side of the ship, from the half-deck to the forecastle, being the uppermost bend, which finishes the upper works of the hull in that part, and wherein they put the stanchions which support the waist-trees. This is called the *gunwale*, whether there be guns in the ship or not.

The lower part of any port, where any ordnance is, is also termed the *gunwale*.

Guy; a rope used to keep steady any weighty body from bearing or falling against the ship's side while it is hoisting or lowering, particularly when the ship is shaken by a tempestuous sea.

Guy is also the name of a tackle used to confine a boom forward when a vessel is going large, and to prevent the sail from shifting by any accidental change of the wind or course, which would endanger the springing of the boom, or perhaps the upsetting of the vessel.

Guy is likewise a large slack rope, extending from the head of the main-mast to the head of the fore-mast, and having two or three large blocks fastened to it. It is used to sustain a tackle to load or unload a ship with, and is accordingly removed as soon as that operation is finished.

Gymnastics, if we understand by this word all bodily exercises, may be most conveniently divided into—1. Military exercises; 2. Exercises systematically adapted to develope the physical powers, and preserve them in perfection, which constitutes the *art of gymnastics*, properly so called; 3. Exercises for the sick, a most important branch, which has been very little attended to. The ancients divided their gymnastics into *gymnastica militaria, gymnastica medica* (including under this head our second and third divisions), and *gymnastica athletica*, or, as Galen calls them, *vitiosa*, which were practised by professional athletæ at the gymnastic games, and were in bad repute with reflecting men, even in those times, on account of their injurious effects on the health and morals. The class of gymnastics which we have enumerated under the second head have their origin in the exercises of war and the chase. The preparation of youth for those occupations leads to the introduction of gymnastics; and the chase itself has been considered by many nations as a preparation for war; the Spartans and American Indians are instances. The ancients do not inform us precisely of the origin of gymnastics, considered as a branch of education. We first find them in a systematic form among the Greeks.

The first gymnasium is said to have been established in Sparta. In Athens, always disposed to mingle the element of the beautiful in whatever she undertook, gymnastics were refined, from the rude military character which they bore among the Spartans, into an art; and the gymnasia became temples of the graces. In each, there was a place called *palæstra*, in which wrestling, boxing, running, leaping, throwing the discus, and other exercises of this kind, were taught. Gymnastics were afterwards divided into two principal branches—the palæstric, taking its name from the *palæstra*, and the orchestric. The former embraced the whole class of athletic exercises; the latter, dancing and the art of gesticulation. It is not known, with accuracy, what particular exercises were usually practised in the gymnasia. The enthusiasm for athletic sports among the Greeks, their love of the beautiful, which was gratified in the gymna-

sia by the sight of the finest human forms in the prime of youth, and by the halls and colonnades adorned with statues and pictures and occupied by teachers of wisdom and philosophy, rendered these places the favourite resort of the old and young. Gymnastics even formed an essential part of the celebration of all the great festivals.

After a time, however, the character of the competitors at the Olympian, Isthmian, Nemæan, and other great games of Greece, degenerated, as they became more and more a separate class, exercising, at least in many cases, in buildings exclusively devoted to them. Euripides calls them useless and injurious members of the state. It is not precisely known to what extent their exercises were practised in the gymnasia. The Greeks, as well as the Romans, set a very high value upon the art of swimming. In Sparta, even the young women swam in the Eurotas; and a common phrase of contempt was, "he can neither swim nor write."

Running was also much esteemed, and the Olympiads were, for a long time, named from the victors in the race. Riding on horseback was deemed a liberal exercise. Dancing (by which we are not to understand the modern dancing of the two sexes intermingled, but the art of graceful motion, including oratorical gesture, together with certain formal dances performed at festivals) was likewise indispensable to an accomplished man. Wrestling was also much valued.

There are not many materials remaining, to enable us to judge of the exercises practised by the Grecian women. In later and corrupt times, they took part in the public games with men. With the decline of Greece, the gymnastic art naturally degenerated, and became gradually reduced to the exercises of professional athletæ, which survived for a long time the ruin of the land of their birth. The Olympic games continued to be celebrated several centuries after Christ. Some late travellers have thought that they could find traces of the ancient games remaining even in our day. "You have the Pyrrhic dance as yet," says Byron. The Romans, under the emperors, imitated the gymnasia, as they did every thing Grecian; but their establishments were little better than places of vicious gratification. The thermæ, or baths, in Italy, took the place of the gymnasia in Greece. Among the Romans, gymnastics never became national, as they may be said to have been among the Greeks. There are some indications, indeed, of early gymnastic games,—we mean the *consualia;* but with this stern, martial, and practical nation, gymnastics took altogether a more military character. They were considered merely as preparatory to the military service, or, when they constituted a part of the exhibitions at festivals, were practised only by a particular class, trained for brutal entertainments, at which large bets were laid among the spectators, as is still the custom on our own race-course.

Vegetius gives us information concerning the exercises in which the young soldiers were trained, and they were of a very useful character. When all the acquisitions of the human intellect were lost in the utter corruption of the latter ages of the Roman empire, and the eruptions of wandering barbarians, the gymnastic art perished.

We may date its revival from the commencement of tournaments, the first of which were held in the ninth and tenth centuries in France, and may have had their origin in the military games of the Romans, aided by the martial spirit of the descendants of the German conquerors of France. They received, however, their full perfection from the spirit of chivalry. The first tournaments were fought with blunt weapons, which were called *armes gracieuses.* At a later period, sharp weapons were introduced, and many fatal encounters happened before the eyes of the ladies. About the year 1066, Godefroy de Preuelly collected the rules and customs of tournaments into a code, which was afterwards generally adopted. At a later period, the character of these celebrations degenerated so much, that they were finally prohibited by the pope and the emperor, as the Roman *ludi* had several times been by the emperors. With the superiority which, in the course of time, infantry began to acquire over cavalry, as it always does with the advance of civilization and scientific tactics, and the invention of gunpowder, the institutions of chivalry declined. The heavy steel coats were done away, and the art of skilful fencing began to be introduced.

The first treatises upon this subject appeared in the sixteenth century. The Italians were the first teachers, and three different schools, the Italian, French, and German, were soon formed. We speak here of fencing with the small-sword; but the Germans also practised the art of fencing with a straight broad-sword, perhaps owing to their neighbourhood to the Sclavonian nations, who all prefer the cut to the thrust. The weapon of the Sclavonians, however, is the crooked sabre. At the same time, vaulting began to be much practised. The Roman *desultores,* indeed, lead us to suppose that the Romans knew something of this art; and it was no doubt also practised by the knights of the middle ages; but the present art of vaulting is modern in its character, and carried to the greatest perfection in France. Fighting with a dagger, and even with a knife, was taught, as useful, in this turbulent age, and much skill was attained in Holland, in defence, by the weapon last mentioned. Wrestling, as an art, was also revived, and many treaties were written on it in the sixteenth and seventeenth centuries, from which we learn that it was often practised in connection with boxing, forming the same compound as the ancient *pancratium.* The famous painter, Albert Durer, wrote *Armorum tractandorum Meditatio* (in 1412). It still exists in manuscript at Breslau. Modern horsemanship had its origin in Italy, and the first riding-school was established at Naples. In the reign of Henry VIII. it was introduced into England. Running, shooting, hurling, leaping, were not taught systematically; yet much importance was attached to proficiency in them, in many parts of Europe, on account of the numerous popular meetings, like those which still exist in Switzerland. Swimming, at this period, was not taught as an art. Where there were convenient places for bathing, children naturally learned it. Elsewhere little pains were taken to instruct them in this useful branch of gymnastics; though in many parts of Europe there were races on and in the water.

The Greeks had, besides the combat with the *cæstus,* a contest of boxing termed *sphæromachia,* because the combatants had balls in their hands. Boxing, taught with caution, is an invigorating exercise, and the skilful boxer is always furnished with natural arms. The art of cudgel-playing is a useful exercise,

as practised in France, where it is different from that which is practised in England. In the last century, when men broke loose from the yoke of authority, and thinking and thoughtless heads began to speculate deeply or frivolously on the existing order of things, education began to receive its share of attention, and the better sort of teachers saw that gymnastics must soon be introduced among the other branches of instruction. Salzmann, a German clergyman, was the first instructor of youth at whose institution in Thuringia bodily exercises were taught, in the latter part of the last century. These were principally running, leaping, swimming, climbing, and balancing. Guts-Muths wrote a very respectable treatise upon modern gymnastics, which, as the first, deserves much praise. He afterwards wrote a more enlarged work on the same subject.

A German of the name of Volker established the first gymnasium in London. At the same time, Captain Clias, a Swiss, established a gymnasium at Chelsea, in the Royal Military Asylum. He soon after published his work on gymnastics, the chief merit of which is its brevity and clearness. Dr. Jahn and his pupil Eiselen published, soon after the peace of Paris, a work on modern gymnastics, which is excellent in many respects, though it is sometimes too minute and pedantic.

Gymnasia have since been opened in various parts of Germany, but they are now strictly confined to bodily exercises. In 1825, Doctor Beck, a German, and pupil of Doctor Jahn, established the first gymnasium in the United States of America. Others have been subsequently established in different parts of the country. It generally happens, that the pupils of a gymnasium after a while lose their interest in the exercises. This was observed even in Germany, where patriotic feelings were mingled with the exercises. The reason of this appears to be, that little or no difference is made in the exercises of different ages, and it is natural that an exercise repeated for years should become wearisome. Gymnastics therefore, when they are taught as a regular branch of education, ought to be divided into two courses. In the first course we would include walking and pedestrian excursions; elementary exercises of various sorts; running, 1. quick, 2. long continued; leaping in height, length, and depth; leaping with a pole, in length and height; vaulting; balancing; exercises on the single and parallel bars; climbing; throwing; dragging; pushing; lifting; carrying; wrestling; jumping, 1. with the hoop, 2. with the rope; exercises with the dumb-bells; various gymnastic games; skating; dancing; some military exercises; swimming, which we include in the first course, because it can be easily taught to children. Some of these exercises, of course, are not suitable for very young children, and they should be distributed in a regular gradation, which caution and experience will teach.

Gymnastics, properly so called, may be begun by a boy from six to eight years old. The second course consists of repetitions of some of the former exercises of vaulting, both on the wooden and the living horse, either standing or running in a circle; boxing, driving, riding on horseback, and fencing with the broad-sword and the small-sword. Fencing with the small-sword is one of the noblest of gymnastic exercises. No other is so well entitled to the name of an art; no other calls the powers into such active exercise; no other requires such quickness of limb, of mind, and of eye, together with so much self-possession; no other developes so completely the whole frame. It is a noble art. Riding, indeed, deserves likewise the name of an art, in which a man may make continual improvement. It cannot, however, be called so pure a gymnastic exercise as fencing, and, in its nature, it is more mechanical. Many excellent horsemen are men of very inactive or limited minds; but all good fencers whom we have known were men of quick apprehension and lively intellect. This accounts for the circumstance that the artists of the middle ages valued fencing so highly. Almost all the great masters and distinguished poets of those times were skilful swordsmen, and some of them, as Leonardo da Vinci and Bacculio, wrote treatises on the use of their favourite weapon. Boxing, riding, and the various exercises on the living horse, should not be commenced much before the sixteenth year.

Gypsum, sulphate of lime, or common plaster of Paris, is found in a great variety of forms. It is either in regular crystals, in which form it is sometimes called *selenite*, or in large crystalline plates and masses, which is perfectly transparent, and as pure as the finest plate-glass; or it occurs in fascicular or radiated masses, which are also crystallized; it is sometimes found in snow-white, scaly flakes, like foam or snow; it is at other times semi-transparent, like horn; and, lastly, it is met with most commonly in large, fine or cross-grained compact masses, forming rocks, and constituting large and extensive strata. In this form, it exhibits a great variety of colours—white, red, brown, bluish-white, &c. The variety of gypsum last described constitutes all the hills and beds of this mineral, which are so frequent among secondary rocks, and in what are called the *salt* and *coal formations*. It occurs rarely, if ever, among the primitive rocks, and not often among those of the transition class. It is almost always found associated with the rock salt, whereon salt-springs are found. It contains but few vegetable or animal remains; those that occur are chiefly bones of quadrupeds, amphibia, fresh-water shells, and vegetable remains. Caves are of frequent occurrence in gypsum.

The purer semi-transparent specimens of gypsum are used for ornamental works, in vases, urns, &c., and for statuary; for which purposes its softness makes it very useful, and easy to work; but this also renders it difficult to polish. In this last form, it is the alabaster of the arts. It constitutes the material used in making the fine plastering for the internal finishing of costly edifices, and gives the walls a most beautiful whiteness. It is also used, after being burned, for the composition of stucco-work of all sorts. But the great and important use of gypsum, or *plaster*, as it is usually called, is for manuring grass and grain lands; in which cases it is truly invaluable. And it is inconceivable how great an additional quantity of grass will be obtained, by the sprinkling a peck of ground plaster upon the acre of land. It is certainly the cheapest and best manure for grass or grain when it can be readily procured.

HAIL appears to be a species of snow, or snowy rain, which has undergone several congelations and superficial meltings, in its passage through different zones of the atmosphere, some temperate and others frozen. It is generally formed in sudden alternations of variable weather. Hail-stones are often of con-

siderable dimensions. They sometimes fall with a velocity of 70 feet a second, or about 50 miles an hour. Their great momentum, arising from this velocity, renders them very destructive, particularly in hot climates. They not only beat down the crops, and strip trees of their leaves, fruits, and branches, but sometimes kill even large beasts and men. The phenomena attending the formation and fall of hail are not well understood. But it is certain that they are connected with electricity. This fact we find noticed by Moses, who relates that "the Lord sent thunder and hail, and the fire ran along upon the ground" (*Gen.* ix. 23). This has been supposed to account for the great variations of temperature to which the hail has been subjected, in its passage through the different strata of the atmosphere. Artificial hail can be produced by an electrical apparatus, and volcanic eruptions are often followed by a fall of hail-stones of great size. Hail-rods have been erected at the suggestion of Volta, in countries much exposed to the ravages of hail storms, on the same principle as lightning-rods. They consist of lofty poles, tipped with metallic points, and having metallic wires communicating with the earth. By thus subtracting the superabundant electricity from clouds, he imagined that the formation of hail might be prevented. These rods are used in Germany and Switzerland, but their success is not proportionate to the expectations entertained of them. The violence with which hail is discharged upon the earth, under an oblique angle, and independently of the wind, would be explained by Volta's supposition, that two electrical clouds are drawn towards each other in a vertical direction, and by their shock produce hail, which, by the law of the composition of forces, would be projected in the diagonal of its gravity, and of the result of the direction of the clouds. In Germany, there are companies which insure against damage by hail.

HAIR; the fine, threadlike, more or less elastic substance, of various form and colour, which constitutes the covering of the skin, particularly of the class of mammalia. It is of a vegetative nature, and appears also in animals of the lower orders, and indeed in all animals which have a distinct epidermis; therefore in insects. In the crustaceous animals, it sometimes appears in particular places, as the feet, on the margins of the shell, on the outside of the jaws, and grows in tufts. Hair is most distinctly developed in those insects—as caterpillars, spiders, bees, &c., which have a soft skin; in this case, it even appears of a feathery form; and butterflies are covered all over with a coat of woolly hair, of the most variegated and beautiful colours. The same variety and brilliancy is displayed in the feathers of birds, which may be considered as analogous to hair, whilst the two other classes of animals—fishes and reptiles—have no hair whatever. No species of mammalia is without hair in an adult state, not even the *cetacea*. In quadrupeds, it is of the most various conformation, from the finest wool to the quills of a porcupine or the bristles of the hog. The hair which is spread over almost the whole of the skin is comparatively short and soft. On particular parts, a longer, thicker, and stronger kind is found; as, for instance, the mane, fetlocks, and tail of the horse, the lion's mane, the covering of man's occiput, his beard, the beard of goats, &c.

The colour of the hair generally affords an external characteristic of the species or variety; but climate, food, and age produce great changes in it. The human body is naturally covered with long hair only in a few parts; yet the parts which we should generally describe as destitute of it produce a fine, short, colourless, sometimes hardly perceptible hair. The only places entirely free from it are the palms of the hands and the soles of the feet; but the body of the male often produces hair like that of the head, on the breast, shoulders, arms, &c. Each hair originates in the cellular membrane of the skin, from a small cylindrical root, which is surrounded by a covering or capsule, furnished with vessels and nerves, called the *bulb*. The root is tubular, and contains a clear gelatinous fluid. The pulp on which the hair is formed, passes through the bottom of the bulb, in order to enter the tube of the hair, into which it penetrates for a short distance, never, in common hairs, reaching as far as the external surface of the skin.—According to Vauquelin, black hair consists of, 1. an animal matter, which constitutes the greater part; 2. a white concrete oil, in small quantity; 3. another oil, of a grayish-green colour, more abundant than the former; 4. iron, the state of which in the hair is uncertain; 5. a few particles of oxide of manganese; 6. phospate of lime; 7. carbonate of lime, in very small quantity; 8. silex, in a conspicuous quantity; 9. lastly, a considerable quantity of sulphur.

The same experiments show that red hair differs from black only in containing a red oil, instead of a blackish-green oil; and that white hair differs from both these only in the oil being nearly colourless, and in containing phosphate of magnesia, which is not found in them. The human hair varies according to age, sex, country, and other circumstances. With the seventh month, the first traces of hair on the head are visible in the embryo. At birth, an infant generally has light hair: it always grows darker and stiffer with age. The same is the case with the eyelashes and eyebrows. At a later period, it begins gradually to lose its moisture and pliability, and finally turns gray, or falls out. These effects are produced by the scanty supply of the moisture above mentioned, and a mortification of the root. But age is not the only cause of this change; dissipation, grief, anxiety, sometimes turn the hair gray in a very short time. It begins to fall off on the top of the head. The hair of men is stronger and stiffer; that of females longer (even in a state of nature), thicker, and not so liable to be shed.

Blumenbach adopts the following national differences of hair:—1. brown or chestnut, sometimes approaching yellow, sometimes black, soft, full, waving; this is the hair of most nations of central Europe; 2. black, stiff, straight, and thin, the hair of the Mongolian and native American races; 3. black, soft, curly, thick, and full hair; most of the inhabitants of the South Sea Islands have it; 4. black, curly wool, belonging to the negro race. The hair, with the nails, hoofs, horns, &c., is one of the lower productions of animal life. Hence, in a healthy state, it is insensible, and the pain which we feel when hairs are pulled out arises from the nerves which surround the root. It grows again after being cut, and, like plants, grows the more rapidly if the nutritive matter is drawn to the skin by cutting; yet, in a diseased state, and particularly in the disease called the *plica polonica*, it becomes sensitive and inflamed to a certain degree, bleeds, and is clotted by a secretion of lymph, which coagulates into large lumps. Hair not only serves as a cover or ornament

to the body, but exercises an important influence on absorption and perspiration; where the hair is thick, the perspiration is more free. If the root is destroyed, there is no means of reproducing the hair; but if it falls out without the root being destroyed, as is often the case after nervous fevers, the hair grows out again of itself. Though hair, in a healthy state, grows only on the external parts of the body, cases are not unfrequent in which it is formed inside of the body in diseased parts.

How much the hair differs in its character from the other parts of the body (being, as we have said, of a vegetable nature), is strikingly shown from the circumstance that it continues to grow after death. As the hair is a very conspicuous object, and capable of much alteration, the arrangement of it has always been one of the most important duties of the toilet.

HAIR'S BREADTH; a measure of length, being the 48th part of an inch.

HALBERT, in *the art of war*, a well-known weapon carried by the sergeants of foot, is a sort of spear, the shaft of which is about six feet long. Its head is armed with a steel point, edged on both sides; but, besides this sharp point, which is in a line with the shaft, there is a cross piece of steel, flat, and pointed at both ends, but generally with a cutting edge at one extremity, and a bent sharp point at the other.

HALF-MOON, in *fortification;* an out-work composed of two faces, forming a salient angle, whose gorge is in the form of a half-moon.

HALF-PIKE; a defensive weapon, composed of an iron spike, fixed on an ashen staff. Its use is to repel the assault of boarders in a manner similar to the defence of the charged bayonet among infantry; hence it is frequently termed a *boarding pike*. It takes the epithet of *half* from its having a much shorter staff than the whole pike.

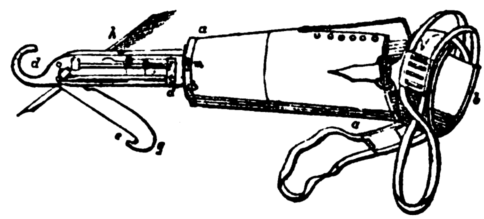
HALO is an extensive luminous ring, including a circular area, in the centre of which the sun or moon appears, whose light, passing through an intervening cloud, gives rise to the phenomenon: those about the moon are most common. When the sun or moon is seen through a thin cloud, a portion of the cloud round the sun or moon appears lighter than the rest, and this luminous disc is called a *corona*. Coronas are of various sizes, but they seldom exceed 10° in diameter; they are generally faintly coloured at their edges. Frequently, when a halo encircles the moon, a corona surrounds it. *Parhelia*, or mock suns, vary considerably in general appearance: sometimes the sun is encircled by a large halo, in the circumference of which the mock suns usually appear, which have often small halos round them.—(See METEOR.)

HAMMER; a well-known tool used by mechanics, of which there are various sorts; but they all consist of an iron head fixed crosswise to a handle of wood. Among blacksmiths there are the hand-hammer, the uphand-sledge, the about-sledge (which is swung overhead with both arms), &c.

HAMMOCK, in *naval affairs;* a piece of hempen cloth, six feet long and three feet wide, gathered together at the two ends by means of a clew, and slung horizontally under the deck, forming a receptacle for a bed. There are about from 14 to 20 inches in breadth allowed between the decks for every hammock in a ship of war. In preparing for battle, the hammocks, with their contents, are all firmly corded, taken upon deck, and fixed in various nettings, so as to form a barricade against small shot.

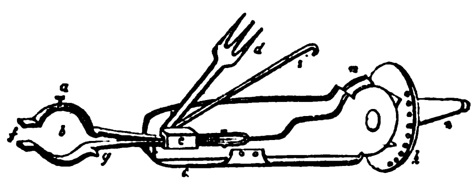
HAND; a very useful part of the human body, which we particularly notice, to call attention to a very ingenious substitute for it, contrived by Mr. Morison.

The inventor of the implements described in this article had the misfortune to lose both his hands, and was from necessity induced to contrive such instruments as might supply the deficiency as far as possible. He made, by the use of his instruments, several neat drawings (now in the possession of the Society for the Encouragement of Arts, &c.) to explain the construction of a great variety of instruments which he had invented at various times, and from among which those now to be referred to were selected, as being some of the most ingenious and useful in their application.



a is a tube or socket, formed of a strong leather, to receive the stump of the arm; it is open at one side next the open end, and has several holes to lace it on tight; but, to prevent any danger of its coming off, it is connected with a band, *b*, encompassing the arm above the elbow by two rings, one of which is marked *a;* the band is fastened by two double straps with a clasp. At the other end of the tube a piece of wood is fitted in, and faced with a circular iron plate; in the centre of this is a socket to receive various implements, one of which, *d*, is represented as affixed to the tube; it terminates in an iron hook, *d*, useful for lifting any article, as a chair, &c., or drawing on boots. The other part of the instrument is made hollow, to receive a button-hook, *e g*, and pen or pencil-holder, F, either of which can be turned out for use; they are retained in the positions of either shut or open by springs similar to that of a knife; behind these, a knife is placed, which can be opened out in a line with the instrument for use, or shut up within the instrument; there is also a hook to open the knife by. The dotted lines, *h*, show the manner in which a pen, or any similar instrument, can be held, the springs of the button-hook and pen-holder being sufficiently strong to hold such articles.

This instrument is adapted to the right arm; the left is provided with a similar leather socket, into which the instrument shown beneath is fitted; it



contains the button-hook *i*, and the fork *d*, either of which can be opened out for use; *c* is the spring by which they are held; *b* is a pair of spring-tongs,

which slide through a socket, and are by that closed up; they have two pair of jaws, one at the end *f*, the other by the side at *g*; *i* is a small hook, by which the tongs can be opened by the button-hook of the other hand. The whole of the instrument bends at a joint *h*, just where it joins the stump, and the end of the spring *e* catches in notches in the joint to hold it sufficiently firm at any particular point where it is set, by pressing the instrument on the knee, a table, or other fixture.

m is the pin which enters the stump; it has a notch all round it at the end, into which a wedge in the stump is received to hold it in; this wedge comes to the outside of the leather in the upper figure, and has a hook by which it can be pulled by the button-hook of the other hand, so as to release the instrument. This wedge does not, however, prevent the whole instrument from turning round in the stump; but by means of holes in the circular plate *h*, and a spring-catch at *m*, which enters any of them, the instrument can be fixed in any position; the catch *m* is relieved by pressing it upon the table, &c.; the instrument can then be turned round, but becomes fixed when the catch is at liberty.

Hand; a measure of four inches. In *painting* and *sculpture*, it signifies also the style of the artist.

Hands, in *heraldry*, are borne in coats of armour, right and left, expanded or open; and a bloody hand, in the centre of an escutcheon, is the badge of a baronet of Great Britain.

Handcuffs; instruments formed of two circular pieces of iron, each fixed on a hinge at the ends of a very short iron bar, which, being locked over the wrists of a malefactor, prevents his using his hands.

Hard-a-Lee; an order to the helmsman to put the helm close to the lee-side of a ship.

Hard-a-Port; an order to put the helm close to the larboard.

Hard-a-Starboard; an order to put the helm close to the right side of the ship.

Hardness, in *physics;* the resistance opposed by a body to impression, or to the separation of its particles. This property depends on the force of cohesion, or on that which chemists call *affinity*, joined to the arrangement of the particles, to their figure, and other circumstances. A body, says M. Hauy, is considered more hard in proportion as it presents greater resistance to the friction of another hard body, such as a steel file; or as it is more capable of wearing or working into such other body, to which it may be applied by friction. Lapidaries judge of the hardness of fine stones, &c., from the difficulty with which they are worn down, or polished.

Harelip is a single or double fissure of the upper lip, by which it is divided into two or three parts, and is thus made to resemble the lip of the hare. Children are not unfrequently born with this deformity. The fissure is sometimes confined to the lip, but more commonly extends to the gums and palate, which it divides into two parts. It produces great difficulty in speech, and besides keeping the mouth open, and thus suffering the saliva to escape, is a dreadful deformity in appearance. It is very common, but, fortunately, is easily curable, so that it seldom goes long unremedied, unless from choice or timidity. The operations for removing this most unfortunate deformity, in its worst forms, are among the merits which have given celebrity to the name of Dessault.

Harmony; the agreement or consonance of two or more united sounds. *Harmony* is either natural or artificial. *Natural harmony*, properly so called, consists of the harmonic triad, or common chord. *Artificial harmony* is a mixture of concords and discords, bearing relation to the harmonic triad of the fundamental note. The word *harmony* being originally a proper name, it is not easy to determine the exact sense in which it was used by the Greeks; but, from the treatises they have left us on the subject, we have great reason to conclude that they limited its signification to that agreeable succession of sounds which we call *air*, or *melody*. The moderns, however, do not dignify a mere succession of single sounds with the appellation of *harmony:* for the formation of *harmony* they require a union of melodies, a succession of combined sounds, composed of consonant intervals, and moving according to the stated laws of modulation.

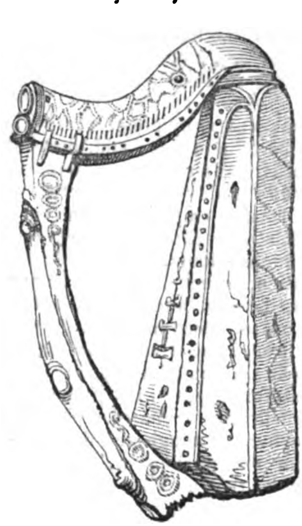
Harmony, Figured, in *music*, is that in which, for the purpose of melody, one or more of the parts of a composition move, during the continuance of a chord, through certain notes which do not form any of the constituent parts of that chord. These intermediate notes not being reckoned in the harmony, considerable judgment and skill are necessary so to dispose them that, while the ear is gratified with their succession, it may not be offended at their dissonance with respect to the harmonic notes.

Harmony, in *painting;* a term used in speaking both of ordonnance and composition, as well as the colours of a picture. In the ordonnance it signifies the union or connection of the figures with respect to the subject of the piece.

Harp; a stringed instrument, consisting of a triangular frame, and the chords of which are distended in parallel directions from the upper part to one of its sides. Its scale extends through the common compass, and the strings are tuned by semitonic intervals. It stands erect, and, when used, is placed at the feet of the performer, who produces its tones by the action of the thumb and fingers of both hands on the strings. The ancients had a triangular instrument, called *trigonum*, corresponding somewhat to our harp. Some authors say that this instrument came originally from the Syrians, from whom the Greeks borrowed it. The ancient *sambuca* is believed by some to correspond to the harp.

Some writers say that the harp came to us from the nations of the north of Europe, in whose languages they trace its etymology. Papias and Du Cange assert that the harp derives its name from the *Arpi*, a people of Italy, who invented it; but Galileo maintains that the Italians received it from the Irish. Whatever may have been its origin, its invention is very ancient. It was known to the Egyptians, as appears from the travels of Bruce and Denon. The four harps of which the latter traveller has given drawings are almost the same in shape as ours. The first two have twenty-one strings, the third eighteen, and the fourth only four. The designs are from the paintings found in the tombs of the kings in the mountains west of Thebes. The Hebrews, the Greeks, and the Romans appear to have made particular use of this instrument. The ivory harp, with seven strings, belonged to the Greeks, who, however, neglected it. The Romans preserved the use of it a long time in sacrifices. The Anglo-Saxons excelled in playing on the harp, which they generally accom-

panied with the violin and the cornicinus. The ancient Irish, Scotch, and Welsh also made much use of this instrument, and the harp figures conspicuously in the arms of Ireland. The Anglo-Normans also were skilful performers on this instrument. Strutt in his *England, Ancient and Modern*, has given engravings of the harps used by the people of the North, about the 9th century. They are triangular, like ours, but have only 12 strings. In the 13th century, the harp had only 17 strings, as appears from a manuscript of the time, cited and analyzed by Lebeuf. No instrument has received greater improvement from modern artists than this. In its present state, while it forms one of the most elegant objects to the eye, it produces some of the most agreeable effects to the ear of any instrument in practice.



We have carefully copied the figure of an ancient harp from a sculptured bas-relief; and it will be seen that in point of picturesque appearance it is not at all behind those which are employed in the present day.

HARPOON. The harpoon is an instrument of iron, of about three feet in length. It consists of three conjoined parts, called the *socket*, *shank*, and *mouth*, the last of which includes the *barbs*, or *withers*. This instrument, if we except a small addition to the barbs, and some enlargement of dimensions, maintains nearly the same form in which it was used in the fishery two centuries ago. At that time, the mouth, or barbed extremity, was of a triangular shape, united to the shank in the middle of one of the sides, and this, being scooped out on each side of the shank, formed two simple flat barbs. In the course of the last century an improvement was made, by adding another small barb, resembling the beard of a fish-hook, within each of the former withers, in a reverse position. The two principal withers, in the present improved harpoon, measure about eight inches in length, and six in breadth; the shank is from eighteen inches to two feet in length, and $\frac{6}{10}$ths of an inch in diameter; and the socket, which is hollow, swells from the size of the shank to nearly two inches in diameter, and is about six inches in length. To this weapon is fastened a long cord, called the *whale-line*, which lies carefully coiled in the boat, in such a manner as to run out without being interrupted or entangled. As soon as the boat has been rowed within a competent distance of the whale, the harpooner launches his instrument; and the fish, being wounded, immediately descends under the water with amazing rapidity, carrying the harpoon along with him, and a considerable length of the line, which is purposely let down, to give him room to dive. Being soon exhausted with the fatigue and loss of blood, he re-ascends in order to breathe, when he presently expires, and floats upon the surface of the water, when the whalers approach the carcass by drawing in the whale-line. The line is from 60 to 70 fathoms long, and made of the finest and softest hemp, that it may slip the easier; if not well watered, by its friction against the boat it would soon be set on fire; and, if not sufficiently long, the boat would be soon overset, as it frequently is. With the harpoon, other large fish, as sturgeons, &c., are also caught.

When the harpoon is forced, by a blow, into the fat of the whale, and the line is held tight, the principal withers seize the strong ligamentous fibres of the blubber, and prevent it from being withdrawn; and, in the event of its being pulled out so far as to remain entangled by one wither only, which is frequently the case, then the little reverse barb, or *stop-wither*, as it is called, collecting a number of the same reticulated sinewy fibres, which are very numerous near the skin, prevents the harpoon from being shaken out by the ordinary motions of the whale. The point and exterior edges of the barbs of the harpoon are sharpened to a rough edge by means of a file. This part of the harpoon is not formed of steel, as it is frequently represented, but of common soft iron, so that, when blunted, it can be readily sharpened by a file, or even by scraping it with a knife. The most important part in the construction of this instrument is the shank. As this part is liable to be forcibly and suddenly extended, twisted, and bent, it requires to be made of the softest and most pliable iron.

Harpoon Gun. The harpoon gun is well calculated to facilitate the capture of whales, under particular circumstances, especially in calm weather, when the fish are apt to take the alarm at the approach of boats within fifteen or twenty yards of them. The harpoon gun was invented in the year 1731, and used by some individuals with success. Being found somewhat difficult and dangerous in its application, it was laid aside for many years. It has, however, subsequently been highly improved, and rendered capable of throwing a harpoon nearly forty yards with effect; yet, on account of the address which is requisite for the proper management of it, and the loss of fish which, in unskilful hands, it has been the means of occasioning, together with some accidents which have resulted from its use, it has not been so generally adopted as might have been expected.

In its present improved form, the harpoon gun consists of a kind of swivel, having a barrel of wrought iron, from twenty-four to twenty-six inches in length, of three inches exterior diameter, and $1\frac{3}{4}$ inches bore. It is furnished with two locks, which act simultaneously, for the purpose of diminishing the liability of the gun missing fire. The shank of the harpoon fired from it is double, terminating in a cylindrical knob, fitting the bore of the gun. Between the two parts of the shank a wire ring slides freely, to which is attached the line. When the harpoon is introduced into the barrel of the gun, the ring with the attached line slides up, and remains on the outside, near the mouth of the harpoon; but the instant that it is fired, the ring, of course, flies back against the cylindrical knob. Some harpoons have been lately made with a single shank, similar to the common hand harpoon, but swell at the end to the thickness of the bore of the gun. The line, closely spliced round the shank, is slipped towards the mouth of the

harpoon, when it is placed in the gun, and, when fired, is prevented from disengaging itself by the size of the knob at the end.

HARPSICHORD; a stringed instrument, consisting of a case, framed of mahogany or walnut-tree wood, and containing the belly, or sounding-board, over which the wires are distended, supported by bridges. In the front the keys are disposed, the long ones of which are the naturals, and the short ones the sharps and flats. These keys being pressed by the fingers, their enclosed extremities raise little upright oblong slips of wood, called *jacks*, furnished with crow-quill plectrums, which strike the wires. The great advantage of the harpsichord beyond most other stringed instruments consists in its capacity of sounding many notes at once, and forming those combinations, and performing those evolutions of harmony, which a single instrument cannot command. This instrument, called by the Italians *clavicembalo*, by the French *clavecin*, and in Latin *grave cymbalum*, is an improvement upon the clavichord, which was borrowed from the harp, and was for more than a century in the highest esteem throughout Europe; but, since the invention of that fine instrument the grand piano-forte, the use of it has considerably diminished.

HARQUEBUSS (in the ancient statutes called also *arquebus*, *haquebut*, or *hagbut*) is a hand-gun, or fire-arm, of a portable length, usually borne on the arm. The word is formed of the French *arquebuse*, and that from the Italian *archibuso*, or *arco a buso* (of *arco*, a bow, and *buio*, a hole), on account of the touch-hole, in which powder is put to prime it, and the circumstance of its having succeeded to the bows of the ancients. The harquebuss is, properly, a fire-arm of the ordinary length of a musket or fowling-piece, cocked, usually with a wheel. Hanzelet describes its legitimate length to be forty calibres, and the weight of its ball one ounce seven-eighths; its charge of powder as much. There is also a larger kind, called *arquebuse à croc*, much of the nature of our blunderbusses. This was used, in time of war, to defend places, being usually rested on something when discharged. The first time these instruments were seen was in the imperial army which drove Bonnivet out of the state of Milan. They were so heavy that two men were employed to carry them.

HARTSHORN; the horns of the common male deer, to which many very extraordinary medicinal virtues were attributed; but the experience of late years gives no countenance to them. The horns are of nearly the same nature as bones, and the preparations from them by heat are similar to those from solid animal substances in general; so that the articles denominated *spirit of hartshorn* and *salt of hartshorn*, though formerly obtained only from the horns of different species of deer, are now chiefly prepared from bones. The former of these, which is a volatile alkali of a very penetrating nature, is an efficacious remedy in nervous complaints and fainting-fits; and the latter has been successfully prescribed in fevers. The scrapings or raspings of the horns, under the name of *hartshorn shavings*, are variously employed in medicine. Boiled in water, the horns of deer give out an emollient jelly, which is said to be remarkably nutritive. Burnt hartshorn is employed in medicine. The horns of the stag are used, by cutlers and other mechanics, for the handles of knives and cutting instruments of different kinds.

HAUTELISSE, and BASSELISSE; French words applied to tapestry. *Hautelisse carpets* are those which are worked with a perpendicular warp, and *Basselisse carpets* those with a horizontal warp. The latter are preferred in modern times, because they are easier to be made, and yet possess equal beauty. In the Netherlands, Brussels and Doornik furnish the best works of this kind; and, in France, the manufactory at Gobelins.

HAZEL; a small shrub or tree very common in most parts of England and America. Both the hazel and filbert are much esteemed, but particularly the latter, the flavour of its kernels being very delicious. They are, however, difficult of digestion, and, when eaten in large quantities, sometimes produce very unpleasant effects. The oil which is obtained from hazel-nuts, by pressure, is little inferior in flavour to that of almonds; and, under the name of *nut-oil*, is often preferred, by painters, on account of its drying more readily than any other of the same quality.—Chemists employ it as the basis of fragrant oils artificially prepared, because it easily combines with and retains odours. This oil is found serviceable in obstinate coughs. If nuts be put into earthen pots and well closed, and afterwards buried eighteen inches or two feet deep in the earth, they may be kept sound through the winter. In many parts of England, hazels are planted in coppices and hedge-rows for several useful purposes, but particularly to be cut down, periodically, for charcoal, poles, fishing-rods, &c. Being extremely tough and flexible, the branches are used for making hurdles, crates, and springles to fasten down thatch. They are also formed into spars, handles for implements of husbandry, and, when split, are bent into hoops for casks. The roots are used by cabinet-makers for veneering; and, in Italy, the chips of hazel are sometimes put into turbid wine, for the purpose of fining it.

HEAD; the part of the animal body which contains the brain and the higher organs of sense. In many animals, it is connected with the trunk by the neck, and is more or less movable; in some animals, however, it is immovable, and is merely a prolongation of the trunk. The head in animals is more distinct in proportion as the brain is more fully developed as the centre of the nervous system. It is entirely wanting in the lowest classes of animals, which, therefore, from the intestinal worms downward, form a third class, in the system of Latreille, under the name of *acephala* (headless animals); while those provided with heads are divided into two classes, the *vertebral animals*, having distinct and proper heads, and the *cephalidia*, having small and less distinctly formed heads. In this part the mouth (see MOUTH), as the opening of the œsophagus, is always situated.

In the second class of animals, in which the head is less distinct, that part of the body which is provided with the mouth may be called the *head end*. In the vertebral animals (mammalia, birds, reptiles, and fish), the head has a bony basis (cartilaginous only in the cartilaginous fishes). In fishes, the bones of the head are not united with each other; and the formation of the separate bones is various. In cartilaginous fishes the head is more or less oblong and angular; in osseous fishes, it is less flattened, and composed of a considerable number of bones connected in various ways; in all fishes, the cavity of the brain is very small and oblong. Equally various

is the formation of the head in the different classes of reptiles. In general, the head is composed of few bones, and more rounded in proportion as the brain is more developed. In birds, the bones of the head are more closely formed into one whole, constituting a skull more or less round, which contains the brain, and to the fore part of which the beak is attached. But the head is most perfect in the mammalia, and resembles the human head more nearly as the animal approaches more nearly to man.

In general, the human head may be considered as the standard, which may be traced, with gradual deviations, through the different classes, until it entirely ceases in the lower orders of animals. Nowhere is its proper office (to serve for the reception of the nervous system) s distinct as in the human head; the cavity of the skull containing the principal organ of sensitive life—the brain; as the great cavities of the trunk contain the chest, the organs of irritable life (the heart and lungs), and the abdominal cavity contains the organs of reproductive life (the organs of digestion and generation). The superiority of the head over the other two parts just mentioned appears, also, from these circumstances, that, whilst it is pre-eminently the seat of the nervous system, it also contains organs essential for functions of the irritable and reproductive system; as the inspiration and expiration of the air are effected through the nostrils and mouth, and the entrance of food into the abdominal cavity, as well as the preparation of it for digestion by mastication and the production of saliva, is effected by the mouth; and these organs appear more prominent in the heads of animals, as their sensitive system sinks lower in the scale.

It must not be forgotten that the head also contains the tongue, an organ not only important in respect to nourishment, but also communicating the desires and thoughts, until it becomes in man the organ of oral intercourse, of language, and of the finest of all music—the human voice in singing. The human head, and, more or less, the head of other animals, is divided into two chief parts, the skull (see SKULL) and the face. The importance of the head, as the noblest part of the animal system, has occasioned it to be used metaphorically, in all languages, to denote that which is chief.

HEART; a hollow, muscular organ, the function of which is to maintain the circulation of the blood, and which is of different formations in different animals. The organs of circulation are the heart, the arteries, the veins, and the capillary vessels. The blood is divided into the arterial blood and the venous blood. The object of the circulation is to carry the venous blood, which has returned from the body, into the lungs, where, by the influence of the air, it is converted into arterial blood, which is then again sent out into the system, to nourish it and repair its losses. The heart in men, quadrupeds, and birds, is composed of four cavities, two auricles and two ventricles (thence called *double*). It is enveloped in a membrane called the *pericardium*, situated towards the left of the cavity of the chest, between the lungs, and resting on the diaphragm. Its form is that of a cone flattened on its inferior and superior faces, the latter formed principally by the right, the former by the left auricle and ventricle.

The right auricle communicates with the right ventricle, besides which there are in it three openings, that of the *vena cava inferior*, that of the *vena cava superior*, and that of the coronary vein. The communication between this auricle and ventricle is closed by a valve when the heart contracts. The right or pulmonary ventricle communicates with the pulmonary artery, which is provided with three valves. When these valves are brought together, they interrupt the communication between the ventricle and the artery.

The left auricle communicates with the left ventricle, and contains also the orifices of the four pulmonary veins. The left ventricle, besides the communication with the left auricle, contains the orifice of the aorta. The ventricles are divided from each other by a fleshy wall, called the *septum cordis*. The valves at the openings of the arteries are called *semilunar;* that at the orifice of the right auricle, *tricuspid;* that at the orifice of the left auricle, *mitral;* and that at the orifice of the *vena cava inferior*, the *Eustachian* valve.

The heart, which with its immediate appendages of veins and arteries, is shown in the accompanying engraving, is formed of a firm, thick, muscular tissue, composed of fibres, interlacing with each other. It is also composed of nerves, membranes, and vessels. The coronary arteries arise from the aorta, and are distributed in the heart. The coronary veins return the blood of the heart into the right auricle. The arteries are the vessels which serve to carry the blood from the heart to all parts of the body. They terminate in the capillary vessels, a series of extremely minute tubes, which pass over into the veins.

The veins are the channels by which the blood passes back from the body into the auricles of the heart. The blood which is returned from the veins is black, and is called *venous;* that which leaves the heart is red, and is called *arterial*. The red blood, possessing nourishing and vital properties, rises in the capillary system of the lungs, flows into the pulmonary veins, thence is received into the left cavities of the heart, from which it passes into the aorta, and is transmitted to all parts of the body, to the capillary system. It there loses two degrees of temperature, and undergoes other changes, by the loss of some of its elements in the important functions of nutrition, calorification, and the secretions. It is now become black, passes through the veins, from the extremities of the body towards the heart, receives the chyle and the lymph, and is emptied into the right cavities of that organ, which returns it, through the pulmonary artery, to the capillary vessels of the lungs, where it is subjected to the influence of the air, resumes the qualities of red or arterial blood, and is ready for a new course.

Having thus described the route of the blood through the different parts of the system, we will now explain the mechanism of the sanguineous system. The blood contained in the two *venæ cavæ* is poured into the right auricle, which contracts, and

thus forces the fluid to escape; but the *vena cava superior* opposes to its passage the column of blood which it contains, the other veins are closed by valves, and it must therefore pass into the right ventricle. The ventricle then contracts, and, the tricuspid valve closing the passage through which the liquid entered, it is forced forward into the pulmonary artery, which contracts, and, its orifice being closed by the semi-lunar valve, propels the blood still forward into the capillary system of the lungs, whence it passes into the pulmonary veins, which pour it into the left auricle by their four orifices. The contraction of the auricle impels it into the left ventricle, by which it is, in the same manner, driven forward into the aorta (the mitral valve preventing its return into the auricle), and thence into the general circulation as above described. The two auricles contract and dilate simultaneously with each other, as do also the two ventricles. The dilatation is called *diastole;* the contraction, *systole*. It is difficult to determine what quantity of blood the heart projects at each systole. It is generally estimated at two ounces. The causes of the alternate contraction and dilatation of the heart are not less difficult to decide. They are entirely involuntary and dependent on the nervous system. The force of its contractions is likewise unknown. The systole of the ventricles is the cause of the motion of the blood in the arteries, which also dilate with each wave driven into them by the motion of the heart.

By what means the blood is made to penetrate the thousand windings of the capillary system, and what causes impel it to flow back through the veins, are yet subjects of dispute among physiologists. The time in which a drop of blood completes its circle of motion has been differently estimated, at from twenty-four hours to a few minutes. Among the lower orders of animals, the organization of the circulating system is very different. The infusoria, polypi, and intestinal worms have no distinct vessels, much less a heart; the echinodermata have distinct organs of circulation, but no part resembling a heart. Insects have a small cylindrical vessel, running along the back, which is rather the rudiment of a vascular system than of a heart. The first traces of a heart are found in some worms, in which some expansions are perceptible in a part of the vessel which runs the whole length of the body. In the spiders, lateral vessels are given off from the main vessel, and a pulsation is perceptible. The crustacea have a heart composed of one fleshy ventricle. In the mollusca, the heart appears completely formed; some of them have three cavities. The four classes of vertebral animals have red blood; but fishes and reptiles have only what is called a *single heart,* that is, composed of one auricle and one ventricle.

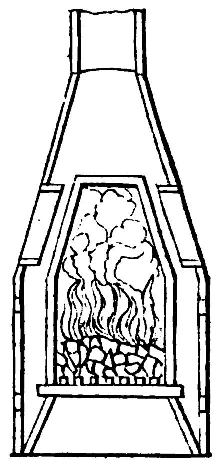
HEAT. See CALORIC and TEMPERATURE.

HEATING BUILDINGS. The subject of heat and cold, as applied to domestic purposes, has already been discussed under a variety of heads in this work. The theory of *specific heat* will be found under the article TEMPERATURE, and the radiation and reflection of heat may properly be discussed under those heads. The heating of buildings by artificial means is, however, so important as to require a distinct notice.

It is admitted on all hands that open fire-places are of all others the least fitted for heating buildings. On this account, through the whole of the north of Europe, iron or earthenware grates, similar to what we call German stoves, are generally adopted.

The principal objection to the German stove is that, even with the most careful management, it produces a strong and unwholesome effluvia. The atmosphere in its neighbourhood speedily acquires the smell of "burnt air," and the ordinary deposit of dust on the surface of the iron adds to the annoyance. To prevent this inconvenience in the heating of a large building, the heating surface of the stove should be much larger than it is in those generally employed.

If there be space beneath the building, the stove shown in the accompanying engraving will be found both economical and effective. It consists of a large central iron box, surrounded by another box of the same material. Between the two boxes is placed a series of flat plates, through which the air rushes from the outside of the building; and by the rapidity with which it passes prevents the burning, and consequently the empyreumatic odour exhaled from the common stove. The hot air is conveyed by a tube passing from the outer case, and the smoke is carried off by a chimney placed behind.



In some cases *steam* has been found very advantageous, and, though somewhat less economical, is more agreeable, and produces a more equable temperature. The steam-pipes employed for the purpose are usually of large dimensions, and, after it is deprived of its heat, the condensed water returns to the boiler for a new supply.

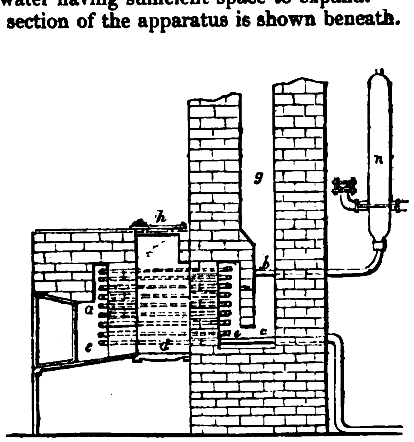
The employment of *hot water* is, in some respects, more valuable. It depends on an arrangement very similar to the circulation of the blood in the human frame. The water in the first instance has its temperature raised in a boiler of the ordinary kind, and, rising to the upper strata, is conveyed away by a pipe at the surface. It will thus pass through many hundred feet of pipe, and ultimately return to the bottom of the boiler, where it remains till its specific gravity is so far diminished as to cause it again to traverse through the same circuit. In this arrangement a temperature much below the boiling point may be advantageously employed.

Mr. Perkins has obtained a patent for some important novelties in the apparatus for heating buildings by the circulation of hot water. These improvements are designed to increase the temperature of the water; and the apparatus is described as applicable also to "a variety of purposes which require the heating medium to be higher than that of boiling water."

The patentee states that his "improvements consist in circulating water in tubes or pipes, which are closed in all parts, allowing a sufficient space for the expansion of the water which is contained within the apparatus, by which means the water will at all times be kept in contact with the metal, however high the degree of heat such apparatus may be submitted to, and yet at the same time there will be no

danger of bursting the apparatus, in consequence of the water having sufficient space to expand."

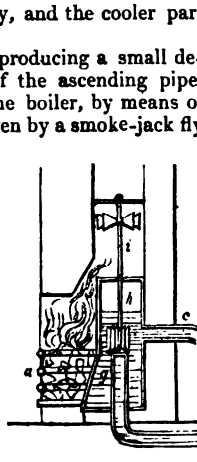
A section of the apparatus is shown beneath.



In this figure, *a* is a coil of tubing, which is placed within the furnace, as shown in the figure; *b* is a tube by which the water passes from the coil *a*, when in a heated state, and *c* is the tube by which the water is returned to the coil, after having given off the heat, to effect the object to which the apparatus is applied, whether for heating the air in buildings, evaporating fluids, heating metal, or other domestic purposes. The furnace consists of two compartments, *d* and *e;* the compartment *d* is that in which the fuel is burned, and the compartment *e* surrounds it, and is a sort of hot chamber, in which the coil of tubes, *a*, is placed, and the water therein becomes heated by the fire in the compartment *d*, the smoke and heated air passing from the ignited fuel into the compartment *e*, and thence into the chimney, *g*. The fuel is supplied at *h*.

There is another patent contrivance that must now be noticed, the particular feature of which is, that the hottest part of the current of water by this improvement is made to descend from the boiler, and the cooler water to rise up into the boiler, which is contrary to the natural course of fluids, where the heated portion ascends by its levity, and the cooler part descends by its gravity.

The contrivance consists in producing a small degree of vacuum over the top of the ascending pipe, which brings the water into the boiler, by means of a rapidly revolving beater, driven by a smoke-jack fly in the chimney. The inventor of this arrangement (Mr. Busby, of Brighton) has suggested a variety of modifications of his apparatus; but its general form will be best understood by a reference to the accompanying diagram. A common fire-grate is shown at *a*, at the back of which is placed the boiler, *g*. The revolving wheel, or beater, is shown at *h*, the smoke-jack fly being above, at *i*. The colder fluid, being thus raised by the vacuum, the hotter is allowed to pass down the pipe *c*, at the reverse end of the range, and hence a continued current of hot water is kept flowing from a boiler placed in any upper part of the building.



Heaven, in a physical sense, is the azure vault which spreads above us like a hollow hemisphere, and appears to rest on the limits of the horizon.—Modern astronomy has taught us that this blue vault is, in fact, the immeasurable space in which our earth, the sun, and all the planets, with the countless host of fixed stars, revolve. The blue colour of the heavens is, according to Nollet, an effect of the light of the sun and stars. According to this explanation, the boundless fields of unillumined space must, like all things else in the absence of light, appear black; but the light of the celestial bodies, which is reflected by the earth to the air, and thence again to the earth, occasions the blue colour. Saussure derives the blue colour, indeed, from the reflected light, but attributes the reflection not to the air, but to the vapours which it contains. He supports his opinion by observing that, if this were owing to the reflection of light from the air, glaciers and mountains covered with snow, seen at a distance of from seventy to ninety miles, would appear blue. That the rays of light are, in fact, reflected by the vapours in the atmosphere appears also from this circumstance, that the heavens, seen from a high mountain, appear of a much darker blue than when seen from a plain; and, even from the latter situation, the blue is very different at different times, and appears dark in proportion to the purity of the atmosphere. Saussure, on the basis of these observations, has invented an apparatus, called a *cyanometer*, in order to determine the quantity of vapour in the atmosphere, from the degree of blueness in the colour of the sky.

Heaven, in the ancient astronomy, denoted an orb or circular region of the ethereal heaven. The ancient astronomers assumed as many different heavens as they observed different celestial motions. These they supposed to be all solid, thinking they could not otherwise sustain the bodies fixed in them; and spherical, that being the most proper form for motion. Thus they have seven heavens for the seven planets, the Moon, Mercury, Venus, the Sun, Mars, Jupiter, and Saturn. The eighth was that of the fixed stars, which was particularly denominated the *firmament*. Ptolemy adds a ninth heaven, which he calls the *primum mobile*. After him, two crystalline heavens were added by Alphonso, king of Castile, to account for some irregularities in the motions of the other heavens; and, lastly, an empyrean heaven was drawn over the whole, for the residence of the Deity; which made, in all, twelve heavens. But others admitted many more heavens, according as their different views and hypotheses required.

Heights, Measurement of. A knowledge of the elevation of a country enables us to determine its climate, to lay out roads and aqueducts properly, and to guard against inundations. The geologist must, in the chart of the country which he wishes to describe, make divisions, according to the most prominent points; but, in order to do this, he must first have a knowledge of the measurement of altitudes. The military man, unless he is acquainted with the altitude of the points upon the chart before him, cannot form an accurate idea of the ground on which he is to execute his plan of operations. The topographer who wishes to represent a country in plaster of Paris, clay, &c., must also be acquainted with all its elevations and depressions. It was, therefore, very im-

portant to invent a method for quickly and accurately determining heights, by a knowledge of the atmosphere, and by the use of instruments, particularly of the barometer and thermometer.

As soon as it was discovered that the air which surrounds our globe was possessed of gravity and elasticity, the operation of which had been perceived on the barometer, it was inferred that its effects on the barometer would be different at different heights in the atmosphere, and that these variations must follow a certain law. Efforts were made to discover this law by experiment. The barometer and thermometer were carried to known heights, observations were there made, and from these observations rules were derived for finding the elevation of a place above the level of the sea. The celebrated Pascal, upon the 19th of September, 1648, on the Puy de Dome, near Clermont, made the first experiment, the result of which he had already anticipated. It appeared that the barometer stood at the height of twenty-six French inches three lines and a half, in the garden of the monastery at Clermont, but at only twenty-three inches two lines upon the summit of the above-mentioned mountain. It followed, as a necessary consequence, that the height of the column of mercury was diminished in the same proportion as the mass of the atmosphere which supported it in the barometer; and Pascal concluded that, by this process, we could determine whether two places were at the same height, or which of them was the higher, even though they were at a great distance from each other.

Succeeding philosophers followed this idea; but the little success which they met with at first shows how many difficulties the subject presented, although it now appears so simple. They had the scales, but were unacquainted with the value of the weights. Barometrical admeasurements first acquired precision and accuracy with Deluc (1754). This philosopher distinguished the effects produced by heat, on the air and on mercury, from those which depend upon their weight; and the improvements which he made form an epoch in the history of the barometer. This history has been written by Pictet, who himself played an honourable part in it. Biot also published inquiries made for the purpose of perfecting the theory of barometrical measurements, and some tables to facilitate the calculations.

Since Deluc's observations the remarkable formula proposed by the author of the *Mécanique céleste* is the most distinguished discovery on this subject. He reduced to a certain point, in a more natural and simple manner, all the corrections which are to be made on account of the influence of temperature, of moisture, and gravity, on the mercury and the air. He rested his theory on the most accurate data; but the co-efficient which he had assumed, in order to represent the relation between the weight of the atmosphere and that of the mercury, appeared to have too little foundation: the formula was to be proved; the length of the columns to be substituted for their weight; many causes of errors remained to be ascertained; the co-efficient was to be improved, or, rather, a new one was to be determined. Ramond has done all this. By a comparison between barometrical observations and actual measurements of the heights where the observations were taken, he has determined the co-efficient, which is contained in Laplace's last formula. Ramond and many other observers have shown, by experiment, that this formula is not only adapted to small as well as great heights, but is also useful in taking measurements under the surface of the earth.

Barometrical observations may attain great accuracy, when they are made with good instruments, by good observers, and under favourable circumstances. In order to ascertain the relative height of two points, two barometers and four thermometers are requisite; two of the thermometers being attached to the barometers, and two of them being free. These instruments must be as simple as is consistent with convenience and accuracy; and they must agree perfectly. The observers must be well acquainted with their instruments, in order to be able to use them; and it is particularly necessary that they should know on what the observations depend. If two or more observers undertake to ascertain the elevation of a place or country by barometrical measurement, they must attend especially to the following particulars:—*a*, that the instruments hang perpendicularly, protected from the sun, and that the free thermometer be raised, at least, nine feet from the ground, and from any objects which might have an influence on their temperature; *b*, the barometers should be accurately regulated, and the degree at which the mercury stands in the barometer and thermometer should be carefully noted; and, *c*, after the instruments are made to correspond, the observations should be made contemporaneously: finally, the observer must be particularly careful to note the state of the atmosphere. Observations should not be taken in stormy weather, or when the quicksilver in the barometer is liable to sudden variations; moderate weather, when the atmosphere is calm, being clear or cloudy, or when there is a light wind, is the most suitable time for making observations. The instruments should not be at too great a distance from each other. The greatest intervening space should not exceed ten miles.

If these general rules for measuring heights by the barometer are attended to, it is far preferable to every other instrument, to ascertain, expeditiously, the height of a mountain, the descent of a river, &c., for a certain space; the relative height of different points, the depth of a cavity, and the thickness of the strata of a mountain. We cannot, indeed, ascertain the fall of a river to an inch by barometrical measurement; but, by careful observations, we may come very near the truth. Tables, founded on Laplace's formula, give great facility in calculating these observations. Among many others, *Tables Hypsométriques* (Paris, 1809) are particularly good, on account of their correctness and adaptation for use. The labours of the distinguished natural philosopher and mineralogist D'Aubuisson (1809), the progress and result of which are detailed in a memoir read before the mathematico-physical class of the institute, at Paris, March 26 and April 9, 1810, are particularly worthy of notice. (See Air, Barometer, and Mountains.)

Heliacal, as applied to the rising of a star, planet, &c., denotes its emerging out of the sun's rays, in which it was before hid. When applied to the setting of the star, it denotes the entering or immerging into the sun's rays, and thus becoming lost in the lustre of his beans. A star rises heliacally when, after it has been in conjunction with the sun and on that account invisible, it gets at such a distance from the

sun as to be seen in the morning before the rising of that luminary.

Heliocentric Place of a Planet is that place in the ecliptic in which the planet would appear if viewed from the centre of the sun; and consequently the heliocentric place coincides with the longitude of a planet, as viewed from the same centre.

Heliometer; an instrument for measuring small distances on the sky, particularly the apparent diameters of the sun and of the moon, more conveniently than can be done with the micrometer. There are different ways of constructing it. The heliometer of Bouguer is an astronomical telescope, provided with two object-glasses, one of which is moveable, and which form two distinct images of the same object, visible through the same eye-glass. If, in contemplating a celestial body, the object-glasses are placed so as to bring the images to touch each other, the distance of the centres of the glasses gives the diameter of the image. In this manner, the instrument gives, for instance, the difference of the diameter of the sun in the perigee and apogee.

Helioscope is a telescope behind which the image of the sun is received upon a plane surface. An astronomical telescope is drawn out a little farther than is necessary for common use, and directed towards the sun. The image which is formed is received in a dark place. For this purpose, a dark chamber is employed, or the telescope is placed in a dark funnel-shaped enclosure, the bottom of which is covered with oiled paper, or closed with ground glass, on which the sun's image is formed. Upon this paper or glass a circle is described equal to the image, and divided, by five concentric circles, into twelve digits. With this instrument the spots on the sun, eclipses, &c., may be observed without injuring the eyes. For greater exactness, however, it is better to observe the sun through a telescope the glasses of which are smoked or coloured. Astronomical telescopes are commonly provided with coloured plane glasses, which may be screwed on when the sun is to be observed.

Hellebore; a plant formerly much used in medicine, and still employed in many species of disease. It has a bitter and acrid taste: the acrimony being felt on the tip of the tongue and then spreading itself immediately to the middle, without being much perceived in the intermediate part. On chewing the root for a few minutes, the tongue seems benumbed, and affected with a kind of paralytic stupor, as when burnt by eating any thing too hot. Black hellebore root, which is a strong cathartic, has been celebrated for the cure of maniacal and other disorders proceeding from what the ancients called *atra-bilis*, in which cases medicines of this kind are doubtless occasionally of use, though they are by no means possessed of any specific virtue. Our black hellebore does not however act with so much violence as that of the ancients, whence many have supposed it to be a different species of plant: and indeed the descriptions which the ancients have left us of their hellebore do not agree with those of any of the sorts usually taken notice of by modern botanists. Vauquelin ascribes its acrimony to a peculiar oil, which he separated from the infusion in alcohol, by distilling off the latter.

Helm; a long and flat piece of timber, or an assemblage of several pieces, suspended down the hind part of a ship's stern-post, where it turns upon a species of hinge to the right or left, serving to direct the course of a vessel, as the tail of a fish guides the body. The helm is usually composed of three parts, viz. the rudder, the tiller, and the wheel, except in small vessels, where the wheel is unnecessary. The rudder becomes gradually broader in proportion to its distance from the top, or its depth under water. The back or inner part of it, which joins the stern-post, is diminished into the form of a wedge throughout its whole length, so that it may be more easily turned from one side to the other, when it makes an obtuse angle with the keel. The length and thickness of the rudder is nearly equal to that of the stern-post. The tiller is a long bar of timber, fixed horizontally in the upper end of the rudder, within the vessel. The movements of the tiller to the right and left accordingly direct the efforts of the rudder to the government of the ship's course as she advances, which is called *steering*.

The operations of the tiller are guided and assisted by a tackle, communicating with the ship's side, called the *tiller-rope*, which is usually composed of untarred rope-yarns, for the purpose of traversing more readily through the blocks or pulleys. In order to facilitate the management of the helm, the tiller-rope, in all large vessels, is wound about a wheel, which acts upon it with the powers of a windlass. The rope employed in this service, being conveyed from the fore-end of the tiller to a single block on each side of the ship, forms a communication with the wheel by means of two blocks, fixed near the mizzen-mast, and two holes immediately above, leading up to the wheel, which is fixed upon an axis on the quarter-deck, almost perpendicularly over the fore-end of the tiller. Five turns of the rope are usually wound about the barrel of the wheel, and, when the helm is a-midship, the middle turn is nailed to the top of the barrel with a mark, by which the helmsman readily discovers the situation of the helm. The spokes of the wheel generally reach about eight inches beyond the rim or circumference, serving as handles to the person who steers the vessel. As the effect of a lever increases in proportion to the length of its arm, it is evident that the power of the helmsman to turn the wheel will be increased according to the length of the spokes beyond the circumference of the barrel; so that, if the helmsman employ a force of 30 lbs., it will produce an effect of from 90 to 120 lbs. upon the tiller (the barrel being one-fourth or one-fifth of the radius of the spokes), which again forming the long end of a lever 10 or 15 times the length of its shorter arm, the force of the rudder will, by consequence, be from 10 times 90 to 15 times 120, or from 900 to 1800 lbs. When the helm operates by itself, the centre of rotation of the ship and her movements are determined by estimating the force of the rudder by the square of the ship's velocity. When the helm, instead of lying in a right line with the keel, is turned to one side or the other, it receives an immediate shock from the water, which glides along the ship's bottom in running *aft*, on the side towards which the helm is turned, and pushes it towards the opposite side, whilst it is retained in this position; so that the stern, to which the rudder is confined, receives the same impression, and accordingly turns in one direction, whilst the head of the ship moves in the opposite. The more the velocity of a ship increases, the more powerful will be the effect of the rudder, because

the water will act against it with a force which increases as the square of the swiftness of the fluid, whether the ship advances or retreats. The direction given in the two cases will of course be contrary. By a late improvement, suggested by Captain Basil Hall, the helmsman is placed in the bow of the vessel, instead of the stern; and this arrangement has been found peculiarly advantageous in steam-vessels.

HELMET; a defensive armour, for the protection of the head, composed of skins of animals, or of metals. Some of Homer's heroes are represented as wearing brazen helmets, with towering crests, adorned with plumes of the tails or manes of horses. Among the Romans, the *cassis* was a metallic helmet; the *galea*, a leathern one.

HELMINTHAGOGA; medicines against worms.

HELMINTHIASIS; the disease which proceeds from intestinal worms.

HEMORRHAGE; a flux of blood from the vessels which contain it, whether proceeding from a rupture of the blood-vessels or any other cause. Hemorrhages produced by mechanical causes belong to surgery; those produced by internal causes, to medicine. The cutaneous system is rarely, and the cellular and serous systems are never the seats of hemorrhages; that of the mucous membranes is the most subject to them. The symptoms of the disease are not less various than its causes and its seats, and the treatment must of course be adapted to all these different circumstances. A hemorrhage from the lungs is called *hemoptysis;* from the urinary organs, *hematuria;* from the stomach, *hematemesis;* from the nose, *epistaxis.*

HEMORRHOIDS, literally, a flow or flux of blood. Until the time of Hippocrates, this word was used, conformably to its etymology, as synonymous with *hemorrhage.* It was afterwards used in a narrower sense, to indicate the flux of blood at the extremity of the rectum, and in some other cases which were considered analogous to it; thus we hear it applied to the flow of blood from the nostrils, the mouth, the bladder, and the matrix. It is at present used to signify a particular affection of the rectum, although the disease is not always attended with a flux; in this sense it is called *piles.* Certain general causes may produce a predisposition to this disease; in some cases, it appears to be the effect of an hereditary disposition; in general, it manifests itself between the period of puberty and old age, although infants and aged people are not entirely exempt from its attacks. The bilious temperament seems to be more exposed to it than any other. Men are oftener affected with it than women, in whom it is sometimes produced by local causes. It often shows itself in persons who pass suddenly from an active to a sedentary life, or from leanness to corpulency. Any circumstance which produces a tendency to stagnation of the blood at the extremity of the rectum is to be reckoned among the local causes. The accumulation of fecal matter in the intestines, the pressure produced by polypi, the obstruction of any of the viscera, especially of the liver, worms, the frequent use of hot bathing, of drastic purges, and particularly of aloes, long continuance in a sitting posture, riding on horseback, the accumulation of water by ascites,—such are some of the ordinary causes of hemorrhoids.

They are distinguished into several sorts, as external, when apparent at the anus; internal, when concealed within the orifice, blind or open, regular or irregular, active or passive, periodical or anomalous, &c. There is also a great difference in the quantity of blood discharged; it is usually inconsiderable, but in some cases is so great as to threaten the life of the subject. The quality, colour, &c., of the blood, also differ in different cases. The number, seat, and form of the hemorrhoidal tumours likewise present a great variety of appearances.

When the disease is purely local, we may attempt its cure; but, in the greatest number of cases, it is connected with some other affection, or with the constitution of the subject. In these cases, if the tumours are not troublesome on account of their size, or if the quantity of blood discharged is not very considerable, the cure may be attended with bad consequences. The best mode of treatment is, then, to recur to hygietic rather than medicinal influences. The subject should avoid violent exercises; but moderate exercise will be found beneficial; the food should not be too stimulating or nutritious. Travelling, or an active life, should succeed to sedentary habits. The constipation, with which the subjects of this disease are liable to be affected, should be remedied by laxatives or gentle purgatives. If bathing is used, it should be in lukewarm or cold water. Any thing which may be productive of a local heat should be avoided; as warm seats, soft beds, too much sleep. If the pain be considerable, recourse should be had to sedatives, gentle bleeding, leeches. If the disease appear under a more severe form, more violent remedies will become necessary. If the sanguineous fluxion become excessive, particular care must be paid to regulate it. If the tumours acquire a considerable volume, surgical operations may become necessary. If any bad consequences result from the suppression of the hemorrhoids, care must be taken to give the blood the salutary direction which it had previously; this may be effected by the use of laxative baths and emollient fomentations.

HEMP. This plant possesses a strong odour, with intoxicating and narcotic properties, on which account it is usual, in India and other Eastern countries, to mix the leaves with tobacco for smoking. It is a native of India and Persia, and was transported into Europe, where it is now cultivated successfully. The seeds do not preserve their vegetative properties beyond one season, on account of the quantity of oil they contain. Their goodness may also be determined by the taste. If an acrid or rancid flavour be present, the seeds have lost the power of germination; all that have a white or pale-greenish colour should likewise be rejected. A strong, heavily-manured soil, is the most suitable for its cultivation, on which account it succeeds so well on newly cleared lands. It should be sown more or less densely, according to the use for which it is intended; if very thick, the fibres are finer, have a better lustre, are more easily bleached, and of course more suitable for the finer kinds of cloth; if scattered sparingly, the plants attain a greater elevation, produce a stronger, coarser, and longer fibre, better adapted for cordage. Care should be taken not to cover the seed too deeply with earth, and, when a few inches high, it should be thinned and cleared of weeds; once is sufficient, for the hemp soon acquires such an ascendency as entirely to prevent the growth of other plants. The harvest is at two distinct periods. Soon after flowering, the male plants should be

pulled up without disturbing the roots of the females, which are to remain some weeks longer, in order to bring the seed to perfection. With unscientific people, however, these terms are transposed, the *males* are called *females* and *vice versâ*. The males should be tied immediately in bundles, the roots cut off while fresh, the upper leaves also beaten off; and it is the most eligible practice to immerse them in water without delay, for rotting. The females, which are three times more numerous than the males, should be pulled very carefully, without shaking or inclining the summits, and the flail should not be used, as it bruises the seed. The seed, when separated, should be spread out, turned at intervals, and exposed to a current of air, otherwise there will be danger of fermentation.

The process of rotting consists in the decomposition of the substance which envelopes and unites the fibres, and takes place much more rapidly in stagnant pools than in running water or extensive lakes—in warm weather than in the reverse. The time requisite varies from five to fifteen days, even in stagnant water. The water in which hemp has been rotted acquires an excessively disagreeable odour and taste, proving fatal to fishes, and should be at a distance from any inhabited place, lest it engender pestilential diseases; neither should it be permitted to corrupt those sources which are used for drink by man or beast. When water is not at hand, hemp may be rotted in the open air, by spreading it at night upon the green-sward, and heaping it together in the morning before the sun's rays have much power. In wet weather, it may be left upon the ground during the whole day, and, should the nights be very dry, it is better to water it. This process is called *dew-rotting*, and is very tedious, requiring three, six, or even eight weeks. Another method, again, is by placing it in a pit, and covering it with about a foot of earth, after having watered it abundantly a single time; but even this method requires double the time of water. After being rotted and rapidly dried, the hemp is ready for combing, beating, &c.; but these subsequent manipulations are found by experience to be very unhealthy, probably on account of the fine, penetrating dust which is created; wherefore, in this instance, at least, the employment of some of the various machines which have been invented is supported on the plea of humanity.

HENBANE possesses a heavy, disagreeable odour, and dangerous narcotic properties. Cases of poisoning, from eating this plant through mistake, have been frequent in Europe. This plant was originally imported from the eastern continent, but has now become naturalized in this country: it occurs in waste places, along road-sides, and in most places where a weed will thrive. From its narcotic qualities, it is occasionally employed in medicine. Twelve species of *hyascyamus* are known, all of them natives of the eastern continent.

HENNA PLANT. This plant grows in moist situations throughout the north of Africa, Arabia, Persia, and the East Indies, and has acquired celebrity from being used by the inhabitants of those countries to dye the nails of their fingers, and the manes, hoofs, &c., of their horses. For this purpose the leaves are dried, powdered, and made into a paste with hot water, which, when applied to the above-mentioned parts, leaves a yellow colour, requiring to be renewed about every three or four weeks. The Egyptian mummies have their nails stained yellow, probably by the use of the henna, though the circumstance is by some referred to the various drugs used in the process of embalming. Henna is cultivated extensively in Egypt, and the powdered leaves form a large article of export to Persia and the Turkish possessions. The colouring matter of this plant is very abundant, and it may be advantageously used for dyeing woollens, not only yellow, but brown of various shades, provided that alum and sulphate of iron be employed.

HERALD. This office is as old as that of the priesthood. Heralds are found among all nations, the *parlementaires* of the moderns being the same as the *heralds* of the ancients. Their persons were inviolable, otherwise they could not have accomplished the object of their institution. The Romans had three sorts of heralds—the *caduceatores, feciales* (heralds of war and peace), and *præcones* (criers or messengers of the superior magistrates). The *caduceator* carried certain plants, as myrtle, olive-branches, rosemary, &c., in his hand, as a symbol of his office, and for his security. Among the Grecians he carried a wand of laurel or olive (*caduceus*). The Athenian herald carried a wand bound round with wool, and ornamented with various kinds of fruits. He often united other employments with his office of herald, as that of cook and cup-bearer. The Spartan heralds must have been derived from *Talthybius*, the herald of Agamemnon, who was worshipped in a temple in Sparta. The *feciales*, forming a college of twenty members, established by Numa, had also a diplomatic character, as their department embraced every thing connected with the declaration of war and the making of treaties. If war was determined upon, they solemnly proclaimed it. If Rome considered herself injured, a *fecialis* demanded satisfaction. If this demand was not complied with within thirty-three days, the *fecialis* went again to the hostile frontiers, threw a bloody spear, and declared war by a solemn formula.

As the frontiers of the Roman territory extended farther and farther from the capital, this ceremony was performed upon a field without the city. The *feciales* wore the sacred *verbena* as a wreath round their temples; and, if they were sent to conclude a treaty, they carried a flint. The *præcones* were employed to proclaim matters of public interest to the people, at religious ceremonies, in the *comitia*, at public sales, judicial trials, in the senate, on the publication of the laws (which they read), at funerals, at games, in the army (if a general wished to address his men), at executions, and at all public meetings. In the middle ages, indigent knights, grown old in battle, were appointed heralds. Their duty was to be arbiters at the tournaments, to pass judgment on coats of arms and the right of knighthood. The study of armouries was therefore indispensable to them; hence the name *heraldry*. They were also the chroniclers of those times, and were present on all occasions of public ceremony.

In France, the first herald (*roi-d'armes*) was crowned and consecrated with religious ceremonies. There were thirty heralds of the realm; the second in rank was called *Montjoye St. Denis*, from the war-cry of King Dagobert. The heralds were united in associations, and their duties formed a branch of science which was communicated only to the members. If

any person pretended to the character of a herald, who, on examination, was found not to belong to the corporation, he was driven away with insults, and sometimes treated with violence. Most of the European orders have their heralds, who are masters of ceremonies. There are three kings at arms in England. The highest is the garter king at arms; the second for the southern provinces; the third for the northern provinces. These three kings at arms, with six subordinate heralds and four pursuivants, form, under the presidency of the Earl Marshal, Duke of Norfolk, the herald's college, or herald's office, established in 1340.

HERALDRY. Arms may belong to individuals, to families, or to countries. Badges and emblems on shields and helms occurred in the earliest times. In Numbers (chap. i. 52), the children of Israel are enjoined to pitch their tents, "every man by his own camp, and every man by his own standard," with the ensigns of his father's house. The poets of the Greeks and Romans speak of paintings and devices on shields and helmets. These symbols were, moreover, hereditary. Thus Xenophon relates that the kings of the Medes bore a golden eagle on their shields. Suetonius asserts that Domitian had a golden beard for his coat of arms; and Tacitus says of the ancient Germans that they marked their shields with brilliant colours, and that certain standards were borne before them in battle. Notwithstanding these traces of armorial bearings in the ancient world, our heraldry is no older than the tournaments. That armoury first became common and regulated by certain rules at these solemn festivals is corroborated by the following reasons:—In the first place, we find no tomb, or monument, with escutcheons, older than the eleventh century. The most ancient monument of this kind is said to be the bearings of Valmond, Count of Vasserburg, in the church of St. Emmeran, at Ratisbon. The shield is *coupé* of argent and sable; over it is a lion, with the words "*Anno Domini MX.*" On most of the other tombs, even of the eleventh century, no arms are found; and the use of them seems to have first become common in the twelfth century.

The first pope who can be proved to have had a coat of arms is Boniface VIII., who filled the papal see from 1294 to 1303. All the earlier papal arms are the fanciful inventions of later historians. On coins, also, no armorial ensigns are found till the thirteenth century. A second proof of our assumed origin of coats of arms is the word *blason*, which denotes the science of heraldry in French, English, Italian, and Spanish. This word has most probably its origin in the German word *blasen* (to blow the horn); for, whenever a new knight appeared at a tournament, the herald had to sound the trumpet, and, because all appeared with close visors, to proclaim and explain the bearing of the shield or coat of arms belonging to each. Because this was performed by the herald, this knowledge was called *heraldry*; and because, in doing so, he blew the trumpet, it was called *blazoning the arms*. That this was a prevailing practice at tournaments may be proved from the poetry of the Troubadours of the twelfth and thirteenth centuries. From the Germans, this custom was transmitted to the French; for there is no doubt that tournaments were usual in Germany much earlier than in France. But the French carried to far greater perfection the tournament, and the blazon or heraldry connected with it, as they did the whole system of chivalry. And, as the French language prevailed at the court of the Norman kings in England, pure French expressions have been preserved in British heraldry. Thus the green tincture (colour) in a coat of arms is termed *vert* (though in French *sinople*), which originally denoted a *reddish brown;* bright red is termed *gules*, probably with an allusion to the bloody revenge of wild animals, which play so conspicuous a part in heraldry. In a *coat of arms*, the helm is placed upon the shield, and the latter is surrounded by the wreath. At a tournament, the mantle of the knight, with the helm and shield, was suspended in the lists. The colours or tinctures of the shields had their foundation in the custom of the most ancient Germans of giving their shields various colours—a custom which received a tender meaning in the tournaments of the middle ages, the knight, bound to defend the honour of dames, and devote himself to their protection, wearing their colours on his shield. By degrees, the partitions or sections on shields came into use; for when, as often occurred, a knight was the champion of several ladies, he bore several colours on his shield, which had therefore to be divided into fields.

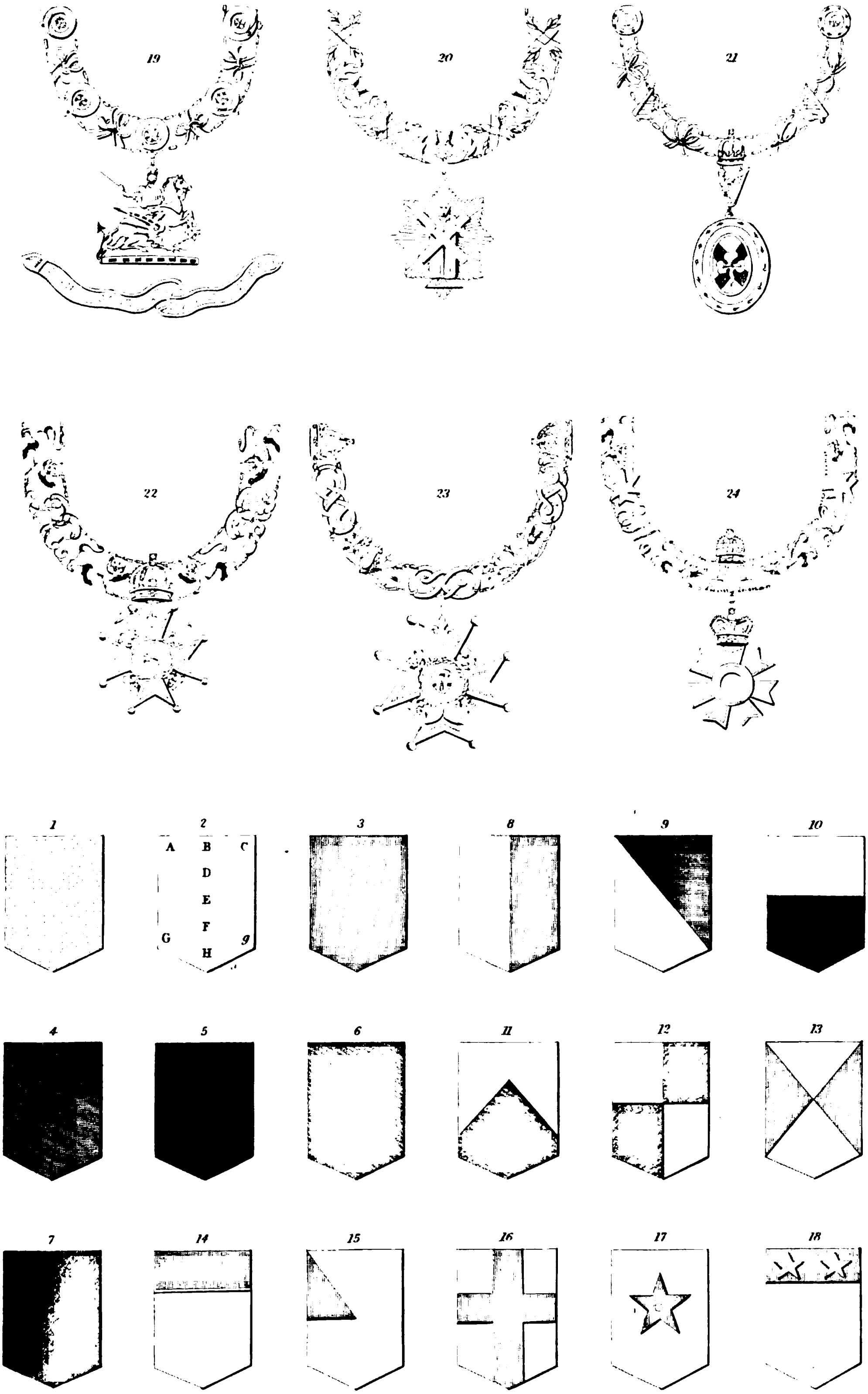
The *escutcheon*, or shield, in arms, means the original shield used in war, and on which arms were originally borne; the surface of the escutcheon is termed the *field*, because it contains such honourable marks as anciently were acquired in the field, &c.

Points of the escutcheon mean certain points or locations, in which the figures or charges of the field happen to be particularly placed. The shield is shown in *plate* I. HERALDRY, *fig.* 2. A signifies that part to be the *dexter chief;* B, the precise *middle chief;* C, the *sinister chief;* D, the collar, or *honour point;* as knights of the garter, thistle, &c., wear their badges of honour about their necks; in like manner is E called the heart, or *fess point*, as being the exact middle of the shield; F, the *nombril*, or navel *point;* G, H, I, the *dexter, middle*, and *sinister* points.

The *colours* used in the science of heraldry are generally *red, blue, black, green, purple;* termed in this science *gules, azure, sable, vert*, and *purpure*. *Yellow* and *white*, termed *or* and *argent*, are metals:

Names.	Colours.
Or	Yellow.
Argent	White.
Gules	Red.
Azure	Blue.
Sable	Black.
Vert	Green.
Purpure	Purple.

Colours and metals, when engraved, are known by points and hatched lines; as *or*, the metal gold, is known in engraving by small dots or points; *argent*, a metal that is white, and signifies silver, is always left plain; *gules*, this colour is expressed by lines perpendicular from top to bottom; *azure*, a colour known by horizontal lines from side to side; *sable*, a colour expressed by horizontal and perpendicular lines crossing each other; *vert*, a colour described by hatched lines from right to left diagonally; *purpure*, a colour known by hatched lines from the sinister chief to the dexter base, diagonally. The colours marked as already described are shown in *plate* I. HERALDRY, *fig.* 1 *to* 7.



Drawn by Charles Blunt. London Published by William Orr Paternoster Row Sept.r 1833 Engraved by J. Dower

Furs are not only used for the linings of robes and of dresses of state, the linings of the mantle, and other ornaments of the shield, but also in the coat-armours themselves: viz. *ermine, ermines, erminois, erminites, pean, vair, vair-en-point, counter-vair, potent-counter-potent.*

Ermine is represented by black spots on a white field; *ermines* is a field black with white spots; *erminois* is a field gold with black spots; *vair* is white and blue, represented by figures of small escutcheons, ranged in a line, so that the *base argent* is opposite to the *base azure; counter-vair* is when the bells or cups of the same colour are placed *base* against *base*, and *point* against *point; potent-counter-potent* is a field covered with figures like crutch-head, termed potents *counter placed*.

Partition lines are such as *party per pale, party per bend, party per fess, party per chevron, party per cross, party per saltire,* by which is understood a shield divided or cut through by a line or lines, either perpendicular, diagonal, transverse, &c., agreeably to the form of the ordinaries. The crooked lines, such as the engrailed, wavy, &c., are used in heraldry to form a difference between bearings which would be otherwise the same; for an escutcheon charged with a chief engrailed differs from a chief wavy as much as if the one bore a cross and the other a saltire.

Party per pale is the field divided by a perpendicular line, as *fig.* 8. Party signifies parted or divided, and is applied to all divisions of the field or charges. Party per bend is a field divided by a diagonal line from the dexter chief to the sinister base, as shown at *fig.* 9. *Party per bend, or, and vert,* name Hawly. Party per fess is a field equally divided by a horizontal line, as at *fig.* 10. Party per chevron is a field divided by such a line as helps to make the chevron, as at *fig.* 11. *Party per chevron, sable and argent,* name Aston. Party per cross, *or quarterly,* is a field divided by two lines, the one perpendicular and the other horizontal, crossing each other in the centre of the field, as at *fig.* 12. *Party per cross, argent and gules,* name Sir Henry Cock, of Hertfordshire. Party per saltire is a field divided by two diagonal lines, dexter and sinister, crossing each other in the centre of the field, as at *fig.* 13.

The crooked lines of partition are the *engrailed, inverted, wavy, nebule, imbattled, raguly, dancette, indented,* and *dove-tail.*

Ordinaries are those figures which, by their ordinary and frequent use, are become most essential to the science, viz: The chief, pale, bend, bend sinister, fess, bar, chevron, cross, and saltire; these have their diminutives.

We may take for an example the *chief,* which is formed by a horizontal line, and contains in depth the third of the field, as shown at *fig.* 14.

The *pale* consists of two perpendicular lines, drawn from the top to the base of the shield.

The pale has two diminutives—the half of the pale is called a *pallet;* and the half of the pallet is called an *endorse.*

The *bend* is formed by two parallel lines drawn from the dexter chief to the sinister base. The bend has four diminutives, the *bendlet,* the *garter,* the *cost,* and *riband.*

The *bend sinister* passes diagonally from the sinister chief to the dexter base of the shield. The bend sinister has two diminutives, the *scarp,* which is half the bend, and the *baton,* which is half of the scarp.

The *fess* is formed by two horizontal lines across the shield, and contains the third part of the field, and is always confined to the centre.

The *bar* is formed by two horizontal lines, and contains the fifth part of the field. The bar is never borne single; the bar has two diminutives, the *closet,* which is half the bar, and the *barrulet,* which is half the closet.

The *chevron* is formed by two lines placed pyramidically, like two rafters of a house, joined together in chief, and descending in form of a pair of compasses to the extremities of the shield. The chevron has two diminutives, the *chevronel,* which is half the chevron; and the *couple-close,* which is half the chevronel.

The *cross.* The cross is formed by the meeting of two perpendicular with two horizontal lines near the fess point, where they make four right angles; the lines are not drawn throughout, but discontinued the breadth of the cross.

The *saltire* is formed by the bend-dexter and bend-sinister crossing each other in right angles.

The *pile* is composed of two lines which form a long wedge.

The *quarter* is formed of two lines, one perpendicular, the other horizontal, taking up one-fourth of the field, and is always placed in the chief.

The *canton* is a square figure like the *quarter,* possessing only the third part of the chief.

A *gyron* is of a triangular figure, composed of two lines, one diagonally from the dexter chief angle to the centre of the shield; the other is drawn horizontal from the dexter side of the shield, meeting the other line in the centre of the field, as shown at *fig.* 15.

Flanches are formed by two circular lines, and are always borne double.

The *orle* is an inner border of the same shape as the escutcheon.

The *tressure* is a diminutive of the orle half in breadth, and is generally borne flory and counter-flory.

The *frett* is composed of six pieces, two of which form a saltire, and the other four a *mascle,* which is placed in the centre.

A *border* is a bearing that goes all round and parallel to the boundary of the shield in form of a hem, and contains the fifth part of the field.

A *border engrailed.* This border is bounded by two small semicircles, the points of which enter the field.

A *border indented* is the same in shape as the partition line indented.

A *border quarterly* is a border divided into four equal parts by a perpendicular and horizontal line.

The *cross* is one of the most important ordinaries. It is borne *indented, engrailed,* &c., as well as plain; but when *plain,* as in the example *fig.* 16, you only mention a *cross,* which is understood to be plain.

A *cross moline* signifies a cross which turns round both ways at the extremities.

A *cross potent.* This cross terminates like the head of a crutch, which anciently was called a potent.

A *cross pattée* is proper for a cross that is small in the centre, and so goes on widening to the ends, which are very broad.

Charges are figures or bearings borne in an escutcheon. We may take the lozenge as an example. The shape is the same with that of a pane of glass in old casements. In this form the arms of maidens and widows should be borne. The true proportion of the lozenge is to have its width three parts in four of its height.

We may now proceed to examine the rules of *blazoning*. This branch of the science of heraldry, according to the *Notitia Anglicana*, is merely employed to describe the things borne in proper terms, according to their several gestures, positions, and tinctures; and how to *marshal* or dispose regularly various arms on a field, in which care ought to be particularly observed, because the adding or omitting any part is oftentimes an alteration of the coat.

In blazon the following rules are to be carefully observed:—

First, in blazoning a coat you must always begin with the field; noticing the lines wherewith it is divided, whether *per pale, per fess, per bend*, &c., as also the difference of those lines, whether *indented, engrailed*, &c.; then proceed to the next immediate charge. By an immediate charge is meant that which lieth next the field, and nearest the centre; this must first be named; and then those that are more remote; for example, *azure, a crescent between three stars, argent*; thus the crescent is first named, as being next the centre of the field. We may take one example of the rules of blazoning: it is shown at *fig.* 18, and is thus described,—*Argent, on a chief gules, two mullets pierced, or.*

We come next to examine the exterior ornaments of the escutcheon, which consist of the helmet, mantling, wreath, crest, badge, motto, supporters, and crown or coronet.

The *helmet*, being placed at the top of the escutcheon, claims our first attention. These pieces of armour for the head have varied in different ages and countries, both in form and the materials of which they were made; viz. those of sovereign princes are of gold; those of the nobility, of silver; and those of gentlemen, of polished steel.

The *mantling* was anciently attached to the helmet; it was used as a covering or trimming which commanders wore over their helmets to defend them from the weather.

Mantlings are now used like cloaks to cover the whole achievement, instead of the ancient mode of representing them as being coverings for the head, or ornaments flowing from the helmet.

The *crest* is the highest part of the ornaments of a coat of arms, and is placed on the wreath. Anciently it was worn on the heads of commanders in the field, and then only in order to distinguish them from others, by their followers.

After the institution of the order of the garter, and in imitation of King Edward III., who was the first king of England that bore a crest on his helmet, all knights companions of the order began to wear crests. This practice soon became more general, until at length they were assumed discretionally by all those who considered themselves as legally entitled to bear arms.

Badges anciently were intended to be placed on banners, ensigns, caparisons, and the breast or shoulders of private soldiers, servants, and attendants, and that without any wreath or other thing under them. Badges were much used from the reign of King Edward I. until that of Queen Elizabeth, when they grew into disuse.

The *supporters* are exterior ornaments, being placed at the sides of the escutcheon to support it. Ministrier says that supporters had their origin from tilts and tournaments, wherein the knights caused their shields to be carried by servants or pages under the disguise of lions, bears, griffins. Moors, &c., who also held and guarded the escutcheons, which the knights were obliged to expose to public view some time before the lists were opened.

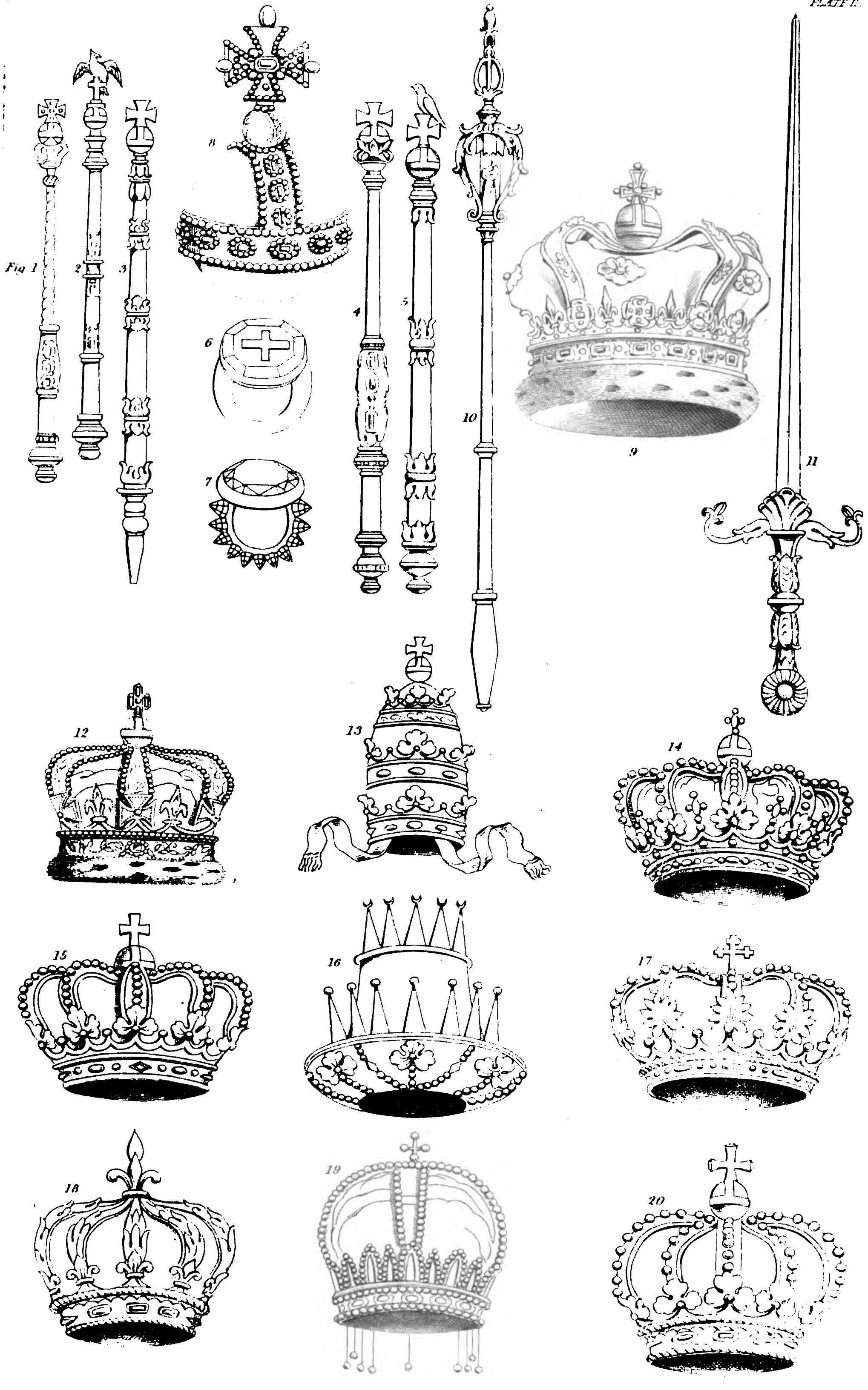
Having thus given a general outline of the principal divisions of heraldry, we may proceed to notice the orders of knighthood. According to the most authentic accounts, the order of the garter was instituted by Edward III., anno 1350, in the twenty-fourth year of his reign. This order, which has ever been considered as the highest in rank and dignity of knighthood, and with which kings and princes of all nations have deemed it most honourable to be invested, consists of the sovereign and twenty-five companions, called knights of the garter. There are besides five principal officers: the prelate, the chancellor, registrar, garter king of arms, and usher, or black rod. The habit and insignia of the order are garter, surcoat, mantle, hood, George, collar, cap, and feathers.

The *garter*, of dark-blue velvet, edged with gold, bearing the motto of "*Honi soit qui mal y pense*," in letters of gold, with buckle and pendant of richly chased gold, is worn on the left leg, below the knee. The *mantle* is of blue velvet, lined with taffeta. The hood affixed to the mantle is of crimson velvet. The *hat* is of black velvet, lined with white taffeta, and adorned with a large plume of white ostrich feathers, with a tuft of black heron's feathers in the centre, affixed to the hat by a band of diamonds. The *collar* is of gold, composed of twenty-six pieces (in allusion to the number of knights), each in the form of a garter, enamelled, blue, with the motto. To which is appended the badge, or figure of St. George on horseback. It is shown at *fig.* 19.

The order of the bath was instituted at the coronation of Henry IV., 1399, who conferred the dignity upon 46 esquires, who had watched during the previous night, and *had bathed themselves*; from which originated the title of knights of the bath. After the coronation of Charles II., who created sixty-eight knights, the order was neglected till the year 1725, when George I. determined to revive and re-organize it, to consist of the sovereign, grand-master, and thirty-six companions; since which time several alterations have been made. In January, 1815, it was declared that, "for the purpose of commemorating the auspicious termination of the long and arduous contests in which this empire has been engaged," the order should be composed of three classes.

The first class to consist of not exceeding seventy-two knights grand-crosses, exclusive of the sovereign and princes of the blood. The badge is commonly pendant by a ring on a broad red riband over the right shoulder, hanging on the left side; but on particular occasions it is worn pendant to the collar, as shown at *fig.* 23.

The knights commanders to be entitled to the distinctive appellation of knighthood, and to have the same rights and privileges as knights bachelors, taking precedence of them. The companions of the order take precedence of esquires, but are not entitled to the appellation of knights bachelors.



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The order of the thistle is supposed to have been instituted by King Achaius, on the occasion of a bright cross, similar to that on which the patron, St. Andrew, suffered martyrdom, appearing in the heavens to him and Thurgus, king of the Picts, on the night previous to the battle gained by them over Athelstane, king of England. Some have thought the order of later date. It was, however, revived in 1540, by James V., of Scotland, and again by James II., in 1679, and has since been re-organized. The order now consists of the sovereign and 12 knights. The *collar* has thistles and sprigs of rue, of gold enamelled, to which is appended the badge, *fig*. 20. The star is worn on the left side, and the jewel is pendant to a green riband over the left shoulder, tied under the arm. Motto—"*Nemo me impune lacesset.*"

The order of St. Patrick was instituted by King George III., February 5, 1783, and consists of the sovereign, grand-master, a prince of the blood royal, and thirteen knights; the Lord Lieutenant of Ireland being grand-master *pro tempore.*

The collar is of pure gold, composed of six harps and five roses, alternately joined together by twelve knots; in the centre is a crown, and pendant thereto by a harp is the badge. The star is of silver embroidery, upon a circular centre *or*, a cross saltire *gules*, surmounted by a trefoil slipped *proper*, each leaf charged with a crown *or*, within a circular fillet of gold, with the motto, "*Quis separabit.*" The collar and star are shown at *fig*. 21.

The Royal Hanoverian Guelphic Order was founded by George IV. when Prince Regent, in 1815, in commemoration of the raising of Hanover into a kingdom, and for rewarding those persons who had performed any signal service to their country. His Majesty, as king of Hanover, is grand-master. The order is composed of three classes, into which civil and military men are admitted, viz. grand-crosses, commanders, and knights. The badges of the military grand-crosses, military commanders, and military knights, differ only in size according to their class. On the reverse, upon the centre, is a double cipher of G. R., with the crown, and date of foundation.

The badges of the civil grand-crosses, commanders, and knights are also alike, only differing in size, having a crown upon the upper limb of the cross (without the swords), by which it is suspended, and a wreath of oak leaves instead of laurel. It is worn on grand occasions suspended from the collar, but on ordinary occasions it is worn pendant from a sky-blue riband scarfwise. Commanders suspend it by a sky-blue riband worn round the neck, and knights by a riband and gold buckle from the button-hole.

The star worn by the military grand crosses is of eight points, &c., with the motto, "*Nec aspera terrent.*" See *fig*. 22. That worn by the civil grand-crosses only differs in the omission of the swords, and a wreath of oak leaves being substituted for laurel.

The order of St. Michael and St. George was also instituted by George IV., when Prince Regent, in 1819, in commemoration of the United States of the Ionian Islands being placed under his sovereign protectorship.

The order is composed of three classes, and consists of the sovereign, a grand-master, a first and principal knight grand-cross, eight grand-crosses, twelve knights commanders, and twenty-four knights, exclusive of British subjects holding high and confidential employ in the service of the United States of Malta.

The collar and badge are worn round the neck on grand occasions; but ordinarily the badge is worn pendant from a red riband with blue edges.

The star worn by the knights grand-crosses is shown at *fig*. 24. That worn by the knights commanders is of a similar description, but of less beauty. Motto, "*Auspicium meliorus ævi.*"

The regalia and crowns of England and Scotland, as well as those of the principal states of Europe, may now be illustrated. The crown of England, with which the kings of England have generally been crowned, is called St. Edward's crown. It is made in imitation of the ancient crown supposed to have been worn by that monarch, and which was kept in the abbey church of Westminster till the beginning of the late civil wars in the reign of King Charles I., when, with the rest of the regalia, it was taken away, and sold in 1642. The present crown was made against the coronation of King Charles II., and is embellished with pearls and precious stones. There is a mound of gold on the top of it, enriched with a band or fillet of gold, embellished also with precious stones. Upon the mound is a cross of gold, embellished likewise with precious stones, and three very large oval pearls, one of them being fixed on the top, and two others pendant at the ends of the cross. It is composed of four crosses pattée, and as many fleurs-de-lis of gold, placed on a rim or circlet of gold, all embellished with precious stones. From these crosses arise four circular bars or arches, which meet at the top in form of a cross. The cap within this crown is of purple velvet, lined with white taffeta, and turned up with ermine.

The golden sceptre, with its cross, is shown at *fig*. 1, *plate* II. Heraldry. It is set upon a large amethyst, of great value, garnished round with table diamonds. The handle of the sceptre is spiral, but the pummel is set round with rubies, emeralds, and small diamonds. The top rises into a fleur-de-lis of six leaves, all enriched with precious stones, from whence issueth a mound made of the amethyst already mentioned. The cross is decorated with precious stones; the sceptre is about thirty-three inches in length.

The sceptre has a dove, the emblem of peace, perched on the top of a Jerusalem cross, ornamented with diamonds. This emblem was first used by Edward the Confessor, as appears by his seal. The length of the sceptre, which is shown at *fig*. 2, is forty-three inches.

St. Edward's staff, in length fifty-five inches and a half, and three inches and three-quarters in circumference, all of gold. This sceptre is carried before the king at his coronation. See *fig*. 3.

The sceptre, *fig*. 4, was made by order of Queen Mary.

The ivory sceptre, *fig*. 5, with a dove on the top, was made for King James II.'s Queen; it is ornamented in gold, and the dove on the top is of gold, enamelled white.

The royal coronation rings are shown at *figs*. 6 and 7.

Fig. 8 represents the golden orb or globe, put into the king's right hand before he is crowned; and borne in his left, with the sceptre in his right, upon his return into Westminster Hall, after he is crowned. It is about six inches in diameter, edged with pearls,

nating the object by association of ideas, and conventional or arbitrary characters, are used together. Of this manner of writing we still find instances among the most civilized nations. The Germans use a †, in works where the saving of space is important, for the word *died*. This is an instance of symbolical hieroglyphics, the cross indicating *death*, either because it was generally planted upon graves, or because it called to mind the death of Him whose death is most important. In the same way they write □ *m.*, for *square miles*. This is a figurative hieroglyphic. The Atlas of Las Cases (Le Sage) is full of symbolical, figurative and conventional, or, as they should rather be called, *arbitrary hieroglyphics*. After the human mind has reached the point abovementioned in the formation of signs, it has two ways of farther progress. It may either generalise the sign, or generalise the thing signified by the sign. The first mode was adopted by the Egyptians. Thus the sign of an eagle, which, in the Coptic, that is, the Egyptian language, was called *ahòm*, was used by the Egyptians for the sound *A* in general. The other direction was taken by the Chinese, who founded their art of writing on the analogy of ideas. Thus, for instance, all the words which express manual labour or occupation are composed, in their written language, of the character which represents the word *hand*, with some other, expressive of the particular occupation intended to be designated, or of the material employed.

Plato tells us that Thoth, secretary to the Egyptian King Thamus, invented the alphabet, and Champollion has actually discovered that the Egyptians had a kind of hieroglyphic writing which was merely phonetic, that is, was composed of a series of signs not having reference to the objects represented, but merely to the sounds of the words expressed. Thus the figurative signs passed over into mere phonetic characters. This was not only the case in Egyptian writing: the names of the letters of the Hebrew alphabet lead us to suppose a similar transformation. We quote the following passage from a note of Professor Moses Stuart to his son's translation of J. G. H. Greppo's Essay on the Hieroglyphic system of M. Champollion. "One need only to read the interpretation of the names of the Hebrew alphabet successively, in order to believe that, originally, there was some analogy between the shape of the respective letters and the objects by whose names they are called. For example, beginning with the alphabet, we proceed thus: *ox, house, camel, hollow, hook, armour, travelling-scrip, serpent, hand, hollow-hand, ox-goad, water, fish, prop, eye, mouth, screech-locust, ear, head, tooth, cross*. These make out the whole original alphabet of the Hebrews; and no one can well suppose that these names rather than others were given to the letters, except on account of some resemblance between them and the objects which bore these names. That the resemblances to these respective objects are not found in the present Hebrew alphabet is no argument against the position; for all critics are agreed that the ancient Hebrew letters have exchanged their forms for those of a later alphabet," &c. So far Professor Stuart. Before we give the system of Egyptian hieroglyphics, according to Champollion's ingenious discoveries, one remark may be allowed to us.

In a certain sense of the word, the course which the Chinese have taken may be considered more philosophical than that of the invention ascribed to Thoth, the former being founded on the combination of ideas, and the latter on the mere external sounds: and yet the latter system has become, at least in our view of the matter (a Chinese, of course, would differ from us), much the more important. By about forty signs we are able to express almost every sound, and, through them, every idea in its various shades (and, with most languages, from twenty-three to twenty-seven signs are sufficient), whilst the Chinese have 10,000 characters in common use. Our system has become much the most abstract, and with this the Chinese reproach it, when they say, "That which enters the mind of a European enters through the ear" (meaning that our letters represent sounds), "while what enters the mind of a Chinese enters through the eye;" and the learned Remusat mentions the lively effect of the Chinese picture-writing, in comparison to that of our conventional signs. Suppose the Chinese to designate the word *tyrant* by a sign which their well-executed writing should show to be derived from a tiger: the ferocity of the man would at once be pourtrayed by the habits of the animal. But the difference, in common cases, is not probably so great as at first appears. In general, if we read a book, the signs do not suggest to us the sounds which they represent, and then the idea (though this is the case with children and illiterate people, who are accustomed to read aloud, or, at least, moving the lips, a proof that, to them, the characters actually represent the sounds), but, from habit, the word suggests an idea. If we read, for instance, a word like *loveliness*, the idea which it represents is not produced within us by the slow process that the characters for *love* reminds us of the sound *love*, and then of the idea, next *li* of *like*, and, at last, *ness* of the sound and the general meaning of this syllable, and then the whole word of the sound *loveliness*, and the idea which this sound is intended to convey; but the whole word presents itself as one sign to the eye, and suggests, at once, the idea of *loveliness*. Now, generally speaking, there is probably the same process in the mind of a Chinese in common cases. He sees the sign, and it produces, at once, the idea. We may remark, too, as an advantage of our mode of writing, that the etymology of a word frequently has a wonderful effect on us, particularly in original languages, as Greek or German, and, to a certain extent, in derivative languages, as Italian and English. With these reservations, we may allow that, in certain cases, the Chinese writing may have a much superior effect upon the mind, by presenting a visible image of the thing signified, since impressions received by the eye are almost always much more lively than those conveyed by sounds. A play, read in a room, does not excite our sorrow or our mirth so much as if we see it represented, and a hundred things may well be said or written, which would be considered highly improper or disgusting if painted or drawn. This explains what Champollion says of the remarkable effect which hieroglyphics have on one who understands them, because they include both symbolic and phonetic characters.

We may now give a survey of the hieroglyphic system. The characters used by the ancient Egyptians, before their conversion to Christianity (after which they adopted the Greek alphabet, with a few supplementary letters), were threefold: 1. hieroglyphic; 2. hieratic; 3. demotic. The first were

composed of images of visible objects; the second, of rude and indistinct outlines of the whole, or of parts of such images; and the third, of a still farther reduction of such outlines in a similar manner. The first kind, from which the others were derived, was originally a real picture-writing, representing ideas by their visible images when possible, or by obvious symbols when any direct representation was impossible. This mode of writing is only suited for a nation in the first stages of civilization, and man would soon discover some more complicated but more perfect mode of representing what is usually expressed by words,—of speaking, in short, by means of visible signs. But words are combinations of sounds, and the next step, therefore, was to devise some method of expressing sounds. As soon as such a device was adopted, any combination of sounds,—that is, any word, whether the name of a visible object or of a mere abstraction,—could be immediately represented to the eye.

The Egyptians, who were, as every day shows more clearly, the most civilized of all nations known to us at a very remote period, arrived at this point very early. They selected several common and well-known hieroglyphics, such as immediately suggested some word of frequent occurrence, and used them to express the initial sound of that word, or, as we should say, its first letter. The more simple outlines or fragments of these hieroglyphics, used in the hieratic character, would therefore have the appearance as well as perform the functions of letters; and when rounded off into the demotic, epistolographic, enchorial or running-hand, would lose all resemblance to the figures from which they were originally derived.

It is plain that these last characters might entirely supersede the use of hieroglyphics, or other symbols, from the facility with which they were formed. We shall see that they actually did so, for the ordinary purposes of life. Thus the demotic characters were, as has been now settled beyond doubt, nearly if not strictly alphabetical. The hieroglyphic character was thus rendered capable of expressing sounds, and consequently words, independently of pictured signs. These signs are, according to Champollion's great work, *Précis du Système Hiéroglyphique*, divisible into three distinct classes: 1. figurative signs, such as were the images of the things expressed; 2. symbolic; 3. phonetic, or expressive of sound. At a later period, probably, a fourth class was brought into use; that of enigmatical symbols, derived either from some very remote affinity between the object represented and the idea implied, or formed by a combination of different figures, apparently incapable of being thus united. We will mention here, in the outset, that Champollion's object, in the work above referred to, is to demonstrate the six following important points:—

1. That the phonetic-hieroglyphical alphabet can be applied with success to the legends of every epoch indiscriminately.
2. Which is, in fact, the consequence of the first statement, that this phonetic alphabet is the true key of the whole hieroglyphical system.
3. That the ancient Egyptians constantly employed this alphabet to represent the sounds of the words in their language.
4. That all hieroglyphical legends and inscriptions are composed principally of signs purely alphabetical.
5. That these alphabetical signs were of three different kinds, the demotic, hieratic, and the hieroglyphical, strictly so called; and,
6. That the principles of the graphic system which he has laid down, and which he proves by a great variety of applications and examples, are precisely those which were in use among the ancient Egyptians.

As all visible objects, with all their parts, and in almost any position, besides an endless variety of arbitrary combinations, come within the scope of the hieroglyphic draughtsman, it might, at first, be supposed that the number of the characters would be almost unlimited: but the necessity of limitation must soon have been felt; for, unless the sense assigned to each character was fixed, the reader would be lost in vague conjectures, and, unless the number of characters was confined within certain bounds, no memory could retain them all. The whole number therefore observed by M. Champollion, after more than twenty years' study, was only 864, of which perhaps some are duplicates. He arranges them in the eighteen following classes:

Celestial bodies	10
Human figures in various positions	120
Human limbs, taken separately	60
Wild quadrupeds	24
Domestic quadrupeds	10
Limbs of animals	22
Birds, either whole or in parts	50
Fishes	10
Reptiles, either whole or in parts	30
Insects	14
Vegetables, plants, flowers, and fruits	60
Buildings	24
Furniture	100
Coverings for feet and legs, head-dresses, weapons, ornaments, and sceptres	80
Tools and instruments of various sorts	150
Vases, cups, and the like	30
Geometrical figures	20
Fantastic forms	50
Total	864

The figures were arranged in columns, vertical or horizontal, and grouped together as circumstances required, so as to leave no spaces unnecessarily vacant, which of course would often have happened had they written their signs successively, as we do our letters, since the signs differ so much in shape and size. Here we must remember that the hieroglyphic writing is eminently monumental. Its special use was in inscriptions that were engraved or sculptured upon public edifices. It is also found executed in similar ways upon objects which preserve the religious or domestic usages of ancient Egypt. It is delineated in numerous manuscripts; also on the wooden coffins of the mummies, and, finally, upon harder substances, such as baked or enamelled earth, &c. Hence, both from the nature of the signs employed, and from the situations in which they were chiefly used, the hieroglyphic writing is a species of painting, and the reason of the rule just stated is therefore easy to be conceived. Beauty of appearance was never forgotten, and Champollion, in his letters from Egypt, dwells on the fine appearance of these various objects, executed with admirable exactness, and often painted with colours, which still continue very bright.

The general order in which the characters are to be perused is shown by the direction in which they are placed, as their heads are invariably turned towards the reader, or, which is the same thing, to that side of the tablet at which the inscription begins, whether it be right or left; for either was admissible in the pure hieroglyphic, though not in the demotic character. To this general rule, Champollion has met with only one exception, which occurs in a hieroglyphical MS. in the royal collection; the figures, therefore, form a sort of procession, and seem, from their relative position, to be connected with each other.

The figurative, or, as they are called, the *pure hieroglyphics*, or the images of the things signified, occur often either in an entire or an abridged but intelligible form; and some of that class were often used merely to determine the sense of the preceeding figures, just as capital letters are employed by us to distinguish proper names or words of peculiar importance. This was the more necessary among the Egyptians, as their names were all significant, and liable to be taken as such, unless accompanied by some indication of their peculiar use. The hieroglyphic of *man* or *woman*, *god* or *goddess*, was consequently subjoined, according to the sex of the person or deity named. Thus the characters expressing *Ammon mai*, when alone, signify *Beloved by Ammon;* but, when followed by that which stands for *man*, represent a proper name, which the Greek would probably have expressed by *Philammon* or *Ammonophilus:* temple, image, statue, child, asp, and monumental pillar, were, in like manner, expressed by figures, evidently representing the things meant. In the bass-reliefs at Medínet-tábu, the scribe recording a victory has a hand with ciphers, expressing 3000, placed in the hieroglyphic column over his head, plainly indicating 3000 heads of men, slain or conquered in battle. Above this is the figure of a man, followed by 1000, evidently signifying 1000 prisoners taken. The figure or outline of a boat, followed by a line signifying *n* (*of*), and the name of a god, signifies the vessel of that god, in which his image or shrine was carried on solemn occasions. *Sun, moon, star, vessel, scales, bed, bull, loaf, sistrum, fish, goose, tortoise, ox, cow, calf, haunch, antelope, bow, arrow, dish, altar, censer, flower-pot, enclosure, chapel, shrine*, &c., are among the words expressed hieroglyphically by images of the objects themselves. These hieroglyphics, therefore, are called, by Champollion, *figurative proper*.

Other terms, such as *sky* or *firmament*, and the names of the different gods, are rendered by very obvious symbols, still in some degree representing the object expressed, at least, according to the notions and dogmas of the Egyptians; the former, by the section of a ceiling, with or without stars subjoined; the latter, by an outline of the animals sacred to the deity to be represented. These are termed *figurative conventional*.

Sometimes only part of the object to be represented is painted or engraved, as the plan of a house, instead of a house itself. These hieroglyphics are called *figurative abridged*. Abstract ideas, however, could not well be expressed by images of visible objects; and metaphors, common in spoken language, when clothed in a visible form, gave birth to a second class of hieroglyphics—that of images used in a symbolical sense. These are the characters generally alluded to by the ancients, when they speak of hieroglyphics; and the circumstance that they are, from their nature, more abstruse and difficult of interpretation, was the occasion of the prevalent but mistaken notion that all the figures on the Egyptian monuments are strictly symbolical—an error which led the learned world, for so many centuries, to such extravagant and contradictory interpretations.

Almost all the figures of speech are, if we may so express it, placed before the eye by this class of hieroglyphics. "Two arms stretched up towards heaven" express the word *offering;* "a censer with some grains of incense," *adoration;* "a man throwing arrows," *tumult*. These instances, therefore, furnish examples of *synechdoches*. *Metonymies* are exhibited in "a crescent, with its horns bent down," for *month;* in "a pencil and a pallette," or "a reed and an inkstand," for *writer, writing, letter*, &c. The "bee," to signify *an obedient people;* "forequarters of a lion," for *strength;* "a hawk on the wing," for the *wind;* "an asp," for *power of life* and *death;* are so many metaphors symbolically expressed. As we are unacquainted with many of the ancient notions, prejudices, &c., and therefore with many of their associations of ideas, and with the transitions of meaning which many signs must have undergone, this class is the one which will always cause the greatest trouble to the decipherer.

An ancient Egyptian writer, Horapollo, tells us that *paternity* and the *world* were expressed by the figure of a "beetle;" *maternity* by a "vulture." Who could have ascertained the signification of these signs, if not assisted by direct information of this kind? The head of the animal sacred to a deity is often placed upon the figure of a man, to signify the deity itself. This certainly produced figures monstrous to us, but it is founded on the notion, which has prevailed among mankind from time immemorial, that some particular animal enjoyed the protection of a particular god. Even at present, in many Christian countries, certain animals are believed to be under the particular protection of certain saints; certain animals, too, are used in paintings, as symbolical accompaniments of apostles and saints.

Now the Egyptians, in writing their hieroglyphics, put the head of this animal upon the statue, instead of putting it by the side of it, as the owl is placed, by the Greeks, by the side of Minerva; thus the figure of a man, with the head of a ram, signified *Jupiter Ammon;* with the head of a hawk, the god *Phré;* with the head of a jackal, *Anubis*, and so on. The gods were also represented by leaving out altogether the figure, and exhibiting only the sacred animal, with some of the divine attributes. Thus a hawk, with a circle on its head, signifies *Phré;* a ram, having its horns surmounted by a feather, or, more generally, by a circle, *Cnuphis*, &c. Lastly, there is a kind of hieroglyphics for the Egyptian gods which we may call either *symbolic or enigmatical;* such as an *eye* for *Osiris;* an *obelisk* for *Jupiter Ammon;* a *nilometer* for the god *Phtha*. Spineto (see lecture iv. of his valuable *Lectures on the Elements of Hieroglyphics*, &c., London, 1829) ascribes these hieroglyphical representations of the deities to the sacred dread which all Oriental nations, and even, in some degree, the Greeks and Romans, had of pronouncing the names of the gods. "And although we find," he says, "these mystic names expressed phonetically in the hieroglyphical legends, yet we are to remember that the characters

themselves were considered as sacred, and peculiarly fitted to be employed in religious matters. This is so true that, in all documents written in the demotic or common characters of the country, the names of the gods and goddesses were invariably written symbolically; just as the Jews never wrote at full length the ineffable name of *Jehovah*, but always expressed it by a short mark, which they pronounced *Adonai*."

Champollion asserts that the Egyptians wrote the names of their principal deity, at least, in one way, and pronounced it in another. As the Egyptians were a very civilized nation, it is clear that hieroglyphics like those described (we mean the figurative and symbolical) could by no means suffice to designate their various wants, occupations, and ideas; and this want may be reasonably supposed to have led to the invention of the third class of hieroglyphics, which M. Champollion calls *phonetic*, as designating a sound. He has also discovered the principle on which these signs were chosen to express one certain sound; it is this, that the hieroglyphic of any object might be used to represent the initial sound of the name of that object.

The following table shows this more clearly: the first column gives the letter expressed by a hieroglyphic; the second, the English name of the object represented; and the third, the corresponding word in the Coptic, or rather Egyptian language.

Letter.	Hieroglyphic.	Egyptian Name.
A,	an eagle,	ahom.
—,	a piece of meat,	af *or* ab.
A, O,	a reed,	aka *or* oke.
B,	a censer,	berbe.
K,	a knee,	keli.
K,	a basin,	knikiji.
G.	———,	gnikiji.
K,	a cup,	klaft.
T, Th,	a beetle,	torres. thorres.
L,	a lion,	laboi.
M,	an owl,	moulaj.
—,	water,	môou.
N,	inundation,	neph.
—,	vulture,	noure.
P, Ph,	mát,	prêsh. phrêsh.
R,	mouth,	rô.
—,	tear	rimé.
—,	pomegranate,	roman.
S,	star,	sion.
—,	child,	si.
—,	egg	soouhi.
T,	hand,	tot.
—,	wing,	ten-h.
SH,	garden,	shnê.
—,	antelope,	shash.
J,	swallow,	jal.
Kh,	fan,	khai.

This principle being admitted, it follows that the number of phonetic hieroglyphics might be increased almost without limit, as the names of a great many different objects might have the same initial sound.

The whole number of elementary sounds intended to be represented was twenty-nine, which is certainly very great for so early an alphabet—a circumstance which deserves still more attention, if we consider that phonetic hieroglyphics were in use with the Egyptians from time immemorial (see *Spineto*, page 95, et seq.). The great number of hieroglyphics which the principle above-mentioned would assign to each of these sounds would have been a continual source of error. The characters, therefore, thus applied, were soon reduced to a few; and, as far as has been hitherto ascertained, eighteen or nineteen is the largest number assigned to any one letter, while few have more than five or six representatives, and several only one or two. The pronunciation of the Egyptian language was probably rapid and indistinct; besides, several dialects were spoken in different parts of the country, and thus consonants were easily interchanged, as we find to be the case at present with so many other languages. This was probably one of the reasons, or the only one, why the vowels were so often left out in the hieroglyphics; just as is the case in Hebrew.

The rule which may be considered as having generally guided, in choosing between so many signs for the same sound, was, to take that sign which seemed most appropriate to the meaning of the word which was to be written phonetically. If the name of a king was to be written, those phonetic hieroglyphics would be taken which represented things of a noble character. The goose, called *chenalopex*, we find usually representing the *S* of *Si*, the word for *son*, on account, as Horapollo says, of the attachment of this bird for its young. If we had to write the word *London* in hieroglyphics, and were to choose between the sign of the *lamb* and of the *lion*, both of which might be used for an *L*, we should certainly take the latter, on account of the heraldic relation which this animal bears to England; and, for the *N*, we might choose, among the many figures capable of representing it, that of a *fishing-net* or a *navy*, as reminding us of the sea, to which London is so much indebted; and so on. Thus the *eagle* is frequently used for *A*, in the names of Roman emperors, and the *lion* for *L*, in those of Ptolemy and Alexander. With the Chinese *hing-ching*, or phonetic signs, a similar choice takes place. This is a great addition in writing certain words, because it assists in conveying a favourable or unfavourable idea, and thereby adds to the force of the word itself. What a scope for wit would such a choice of signs afford, in the correspondence of modern fashionable society!

The Egyptians used a very great number of abbreviations in writing phonetically, of which the late Doctor Young has shown many in the registries of deeds, drawn up under the Ptolemies, and published by him. Though, as we have stated, Champollion considers the phonetic alphabet the true key to the whole hieroglyphical system, yet all the sorts of hieroglyphical characters are used together; and, had not so much already been done by the critical ingenuity of the learned, we should almost despair of ever being able to read inscriptions in which such different signs are used promiscuously; yet it is stated that Champollion has acquired much skill in deciphering these writings, so mysterious for thousands of years, and reads most of them with comparative ease. Those hieroglyphics which are called *enigmatical* may be considered a division of the symbolical. They are a more complicated and obscure kind, probably formed by the *anaglyphs* or allegorical sculptures, mentioned by Clement of Alexandria. They appear to have been bass-reliefs or tablets, containing mythological or historical subjects, expressed in allegorical delineations, or implied by the figures of human beings, with the heads of

birds and beasts, such as those with which the Egyptian temples were filled, and among which we must rank the sphinxes, forming avenues at their entrance. Symbols such as these, grouped and combined according to certain rules, might be so disposed as to form an allegorical representation of the religious and philosophical doctrines of the Egyptians.

None but the initiated were suffered to dive into these mysteries, and the key to them was kept exclusively in the hands of the priesthood. As the ordinary style of hieroglyphics must have been legible for every well-educated Egyptian, a more refined system was devised: a language more strictly ideographical was invented; metaphors, similes, imagery, and allegory were embodied in actual forms, and the links connecting the chain of ideas thus expressed were implied, by the relative position of figures, their attributes, or their ornaments, so as to present to the eye of the initiated an intelligible, and, if such an expression may be allowed, a legible picture, in what appeared to the uninitiated an incoherent tissue of extravagance. "The images of the gods in the sanctuaries, the human beings with heads of beasts, or beasts with human limbs, might be termed," says Champollion, "the *letters* of that secret writing which consisted of the anaglyphs or enigmatical sculptures, forming the fourth class of hieroglyphics." "It was in this sense, probably," he adds, "that the Egyptian priests called the ibis, the hawk, and the jackal, the images of which were carried in procession on certain solemn occasions, *letters*, as being the true elements of a sort of allegorical mode of writing."

It is in the interior of their temples and their sepulchres that these symbolical records are found "distinguishable without difficulty," says the same writer, "from the historical scenes, and civil or religious ceremonies, represented in the bass-reliefs and paintings on the walls of their public buildings." The origin and characteristics of the *hieratic* or sacred character, so denominated to distinguish it from the *demotic*, or popular, have already been briefly stated. It consists of nothing more than imperfect and dashing sketches of the hieroglyphics, which thus assumed the form of a flowing and rapid hand. For figures and symbols, it often substitutes phonetic groups, or arbitrary characters, which bear no resemblance to the hieroglyphics for which they stand. Religion and science, both fostered by the priest, seem to be the only subjects for which this character was used; nor did it undergo any material change in its form and structure, during the many ages through which it was used, resembling, in this respect, the use of a *court hand*, as it was called for centuries, in copying records and other legal proceedings in England and the continent of Europe, and the long continuance of a particular phraseology in legal instruments.

The real hieratic character resembles the Chinese, and is written with as much rapidity. One peculiarity of this character deserves notice here. In hieratic texts, the oval frame enclosing the name of kings, called *cartouche*, is expressed by a semi-circle at the beginning of the word, as might be expected; but at the end, instead of a corresponding curve followed by a straight line, expressive of the remainder of the frame, as is usually the case in the demotic character, three, four, or five dashes, either straight or slightly curved, are substituted for it.

The common Egyptian character, called *demotic* from its popular use, *epistolographic* from its fitness for letter-writing, and *enchorial* from its being peculiar to Egypt and distinct from the Greek, so familiarly known there under the Ptolemies, seems to have been derived from the hieratic by nearly the same process as the latter from the hieroglyphics. It is, however, more simple; not strictly alphabetic, because a small number of images or figures are still found in it; some few symbols, also, connected with religious subjects, occur; but these figures and symbols are almost invariably so curtailed and simplified as to lose all resemblance to the objects expressed. The whole, therefore, has the appearance of a written alphabet. The number of equivalent signs is much smaller, the whole of those which clearly differ from each other not exceeding forty-two. In the direction of the lines from right to left, and in the suppression of many vowels, this system of writing resembles that of the Phœnicians and Hebrews.

Numeration by Hieroglyphics. The units are expressed by single upright strokes, and they are always repeated to mark any number below 10. The number 10 is represented by an arch, either round or angular. The repetition of these arches produces the repetition of as many tens up to 90. A hundred is exhibited by a figure very much resembling our 9. This same figure is again repeated for every 100, for any number below 1000. One thousand is represented by a cross, over which is a figure like Ɔ. Thus, to express the numbers 2, 3, 4, 7, &c., we are to mark 2, 3, 4, or 7 upright strokes. To signify 20 or 90, we are to write 2 or 9 angular or round arches: the number 42, for instance, is expressed by 4 arches, which mean 4 times $10 = 40$, and by two upright strokes, which mean 2. To signify the ordinal numbers, we are to place at the top of each of the numbers a figure, which resembles our 8 placed horizontally (∞); thus a single upright mark, with the horizontal ∞ over it, would signify *first;* and, if this figure be changed into one like three sides of a square, then the numbers will signify the *first time*, &c. (*Spineto*, lect. ii. p. 72). This system, though much inferior to that admirable invention by which the place of the number indicates what product of 10, or 100, or 1000, &c., it is, is yet greatly superior to the Greek and Roman numeration.

HIGH WATER; that state of the tides when they have flowed to the greatest height, in which state they remain nearly stationary for about fifteen or twenty minutes, when the water begins again to ebb. The time of high water is always nearly the same in the same place at the full of the moon, and, at all other times, the time of high water depends upon the age of the moon; the rule for finding which, the age of the moon being given, is as follows, viz.: add four-fifths of the days of the moon's age, as so many hours, to the time of high water at the full of the moon, and the sum is the time of high water answering to that day, nearly.

HOLD; the whole interior cavity or belly of a ship, or all that part of her inside which is comprehended between the floor and the lower deck, throughout her length. This capacious apartment usually contains the ballast, provisions, and stores of a ship of war, and the principal part of the cargo in a merchantman; in the former, it is divided into several apartments (by bulk-heads), which are denominated according to the articles which they contain, as the

fish-room, the *spirit-room*, the *magazine*, the *bread-room*, &c.

The *after-hold* is that which lies abaft the main-mast, and is usually set apart for the stowage of the provisions in ships of war.

The *fore-hold* denotes that part of the hold which is situated in the fore part of the ship, or about the fore hatchway. It is usually in continuation with the main-hold, and serves the same purposes.

The *main-hold* is that part which is just before the main-mast, and which generally contains the fresh water and beer, for the use of the ship's company.

Hollow Square, in the *military art;* a body of foot soldiers drawn up with an empty space in the middle.

Holly is a wood much employed in manufactures. It is very hard, susceptible of a fine polish, and more capable of receiving a black colour than any other: it is used principally for veneering; the black lines with which cabinet work is frequently ornamented are formed of this wood, dyed with sulphate of iron. It is a good wood for turning the cogs of wheels, and for the pulleys of machinery; but for the latter purpose lignum vitæ is preferable.. The European holly is very similar to the American in size, appearance, and the qualities of the wood.

Home-sickness, in medicine *nostalgia*. The natural feeling of grief at a separation from the paternal home and native soil becomes, in men of great sensibility, who go to a different climate (especially from a mountainous to a champaign country), and are surrounded by different scenery, without active occupation, a real disease. It shows itself by a deep melancholy, under which the whole nervous system in a short time suffers. The miud of the patient is filled with thoughts of his country, and with associations which serve to recal it. The desire of seeing it, and despair of gratifying the desire, engross him. As the disease of the nerves increases, spasms come on. The respiration of the individual becomes difficult, interrupted, and consists almost wholly of sighs. His appetite is lost. A deadly paleness extends over all his countenance, and his sight grows dim and weak. His heart beats immoderately, and throbs with the slightest motion. His secretions become irregular; sleep flies from him, or consists principally of dreams, which are filled with the scenes he has left. Sudden death sometimes puts an end to this situation; but more commonly a slow, nervous, and hectic fever ensues, which carries off the individual, if it is impossible to overcome the disease. A return to his home is the most effectual remedy. The confidence that this will happen has cured many. But, when this is impossible, agreeable occupation is a better remedy than medicine. It is a curious fact that those who inhabit mountain districts are much more susceptible of this home-sickness than those born in savannahs or level ground. The love of country exhibited by the Swiss mountaineer has become proverbial.

Homœopathy; the name of a system of medicine, introduced by Samuel Hahneman, and which, for about twenty years, has attracted much attention in Germany, and, of late, in other countries also. The name expresses the essential character of the new system, which consists in this—that such remedies should be employed against any disease as, in a healthy person, would produce a similar, but not precisely the same disease. The fundamental principle of this system is, therefore, *similia similibus curantur*. To find such medicines against any given disease, experiments are made on healthy persons, in order to determine the effect on them. In the conviction that every disease carries with it a great susceptibility for the proper medicine, and that the power of medicine increases by minute division, the homœopathist gives but one drug at a time, and does not administer another dose, or a new medicine, until the former has taken effect. At the same time, a strict diet is prescribed, that the operation of the medicine may not be disturbed. Homœopathy directs the attention chiefly to the symptoms of the disease, which are followed up and observed with much greater accuracy than formerly. Disease is considered by it as only an aggregate of symptoms; and therefore the business of the physician is to extinguish the symptoms. The disciples of this system care little about the customary names and divisions of diseases; they regard only the particular pains and debilities of which the varieties of sickness are composed. The proximate causes of diseases, therefore, are little regarded, though the more remote causes are studied, at least in relation to diet.

Every disease is considered as requiring a specific remedy. Homœopathy is thus placed in opposition to the Hippocratic system, which has existed, under various forms, for twenty-two centuries; and it has been exposed to numerous attacks on this account. We will mention some of the points in dispute. Homœopathy objects to the Hippocratic system, that it acts on the maxim *contraria contrariis curantur*, and therefore effects merely a palliative cure. This reproach is unjust, because the judicious physician endeavours to restore the diseased organs by the influence of the healthy organs, and the merest empiric alone attempts to cure by absolute *contraries*. The Hippocratic medicine does not even reject the homœopathic principle, as the treatment of nervous diseases proves. Secondly, the homœopathists accuse their opponents of directing their efforts against what cannot be known, the proximate cause of the disease; while, in turn, the homœopathist may be reproached with attaching himself merely to the superficial external appearance of the disease, and with a pedantic minuteness in regard to those symptoms which disease assumes in a given case. Thirdly, the homœopathist accuses the others of administering remedies of which they do not know the effects; to which it may be replied that the effect of a medicine becomes perfectly known only through a patient, never by a healthy person. Fourthly, the minuteness of the dose prescribed by the homœopathists is objected to by other physicians, who, however, should not forget that they constantly order a solution of one grain of tartar-emetic in eight ounces of water. The injudicious mixture of medicines has become less common than formerly among the Hippocratic physicians. The Hippocratic school cannot reconcile itself to the idea that all classification of diseases under generic names is, in itself, without meaning, and that the course of acute diseases, the doctrine of the crisis, &c. (the basis of the Hippocratic medicine), is imaginary, since it rests on a faithful observation of nature. The old system, therefore, reproaches homœopathy not only with not knowing, but with disdaining to know the nature of diseases. Since the knowledge of the nature and the course of diseases is the indisputable basis of the Hippocratic medicine, a great revolution in medicine

is not to be expected from homœopathy. If its principles should prove true, it will result in a knowledge of specific means of cure, and thus make a valuable addition to medicine, as other systems have done.

Hone; a species of whetstone, employed for sharpening cutlery. This useful implement is now likely to be superseded by a metallic cylinder, invented by Mr. Knight, President of the Horticultural Society. It is highly spoken of as perfectly effective and much more convenient than an oil-stone, answering all the purposes of a hone, and rendering a strop unnecessary.

This instrument is a cylindrical rod of steel, about a quarter of an inch thick, and five inches long. It is rendered perfectly smooth in the first instance, while in its soft state, and is then worked into extremely fine longitudinal lines, by means of fine emery or glass-paper, previous to the steel being hardened. It has a silver or plated knob at the top-end, by which it is to be held when in use; and, when out of use, it is slipped into a cylindrical sheath, as a guard to its surface.

In using this instrument for sharpening the finer kinds of cutlery, such as razors, its surface is to be first moistened with a small quantity of sweet oil, and a little rotten-stone, or rouge, or indeed any kind of extremely fine grit, is to be powdered upon it. The razor, being then held perfectly flat upon the surface of the cylinder, is to be worked about in the same way as on a hone; and, if it has not been previously rounded by careless setting, the fine lines and the powder upon the steel will very soon bring it to a beautiful smooth cutting edge.

Honey; a valuable product, very similar in its properties to sugar. It is found, in large quantities, in a number of vegetables, is collected by the bee, and is fed upon by many insects. It is always formed in the flower, chiefly at the base of the pistil, and seems designed to receive and retain the fecundating pollen. Honey differs much in colour and in consistence; it contains much saccharine matter, and probably some mucilage, from which it derives its softness and viscosity. It very readily enters into the vinous fermentation, and yields a strong liquor called *mead.* There are two species of honey; the one is yellow, transparent, and of the consistence of turpentine; the other white, and capable of assuming a solid form, and of concreting into regular spheres. These two species are often united; they may be separated by means of alcohol, which dissolves the liquid honey much more readily than the solid.

Honey has never been accurately analyzed, but some late experiments go to prove it to be composed of sugar, mucilage, and an acid. The honey made in mountainous countries is more highly flavoured than that of low grounds; that which is made in the spring is more esteemed than that gathered in the summer; and that of the summer more than that of the autumn: there is also a preference given to that of young swarms. Yellow honey is obtained, by pressure, from all sorts of honey-combs, old as well as new, and even from those whence the virgin honey has been extracted. The combs are broken, and heated, with a little water, in basins or pots, being kept constantly stirring; they are then put into bags of thin linen cloth, and these into a press, to squeeze out the honey. The wax stays behind in the bag, excepting some particles which pass through with the honey.

Honey is the production of most countries; it is, however, more abundant in the island of Candia, and in the greater part of the islands of the Archipelago, than any where else. The Sicilian honey seems to be particularly high-flavoured, and, in some parts of the island, even to surpass that of Minorca, which no doubt is owing to the quantity of aromatic plants with which that country is overspread. This honey is gathered three times in the year, in July, August, and October. It is found, by the peasants, in the hollows of trees and rocks. The country of the lesser Hybla is still, as formerly, the part of the island that is most celebrated for this article. Considerable quantities of honey are produced by the wild bees in the woods of North America. Honey is used in preserves and confectionery, and, in its pure state, to put upon bread; also as a demulcent medicine against hoarseness, catarrhs, &c., and externally, as a softening application, to promote suppuration. In its clarified state, it is used to sweeten certain medicines. It is more aperient and detergent than sugar, and is particularly serviceable in promoting expectoration in disorders of the breast, and as an ingredient in cooling and detergent gargles. For these, and other similar purposes, it is sometimes mixed with vinegar, in the proportion of two pounds of clarified honey to one pint of the acetic acid, boiled down to a proper consistence over a slow fire, and thus forms the oxymel simple of the shops. It is also impregnated with the virtues of different vegetables, by boiling it in the same manner, with their juice or infusions, till the watery parts have exhaled. It is the basis of several compositions in pharmacy, though in this way it is less used than formerly. When collected from poisonous plants, as *rhododendron, ponticum,* &c., it partakes of the qualities of the plants. The inferior qualities of honey, and what remains when it is purified, can be used in the preparation of brandy, vinegar, or any other fermented liquor.

Honey, as may be easily imagined, was one of the first articles of human nourishment. The gods of Greece were supposed to live on milk and honey (ambrosia). Aristotle, Celsus, Pliny, Ælian, and probably the ancients in general, did not know where honey originally came from; they thought it was a dew which fell from heaven. Pliny does not decide whether it issued from the heavens in general or from the stars, or was a juice produced by the purification of the air, and which, afterwards, was collected by the bees. The juice of the flowers, they believed, produced only the wax. Hence we find the honey flowing from the trees in great abundance, in the descriptions which the poets give of the golden age. In the Bible, we find mention made of bees'-honey, grape-honey (must, boiled to a syrup, and still used), and tree honey, which is found upon the leaves of certain trees and shrubs, having been thrown out by certain insects. In all the works on agriculture left by the ancients, we find much importance attached to honey and the care of bees. The ancients also ascribed medicinal powers to honey.

Honey-comb; a waxen structure, full of cells, framed by the bees to deposit their honey and eggs in. The construction of the honey-comb seems one of the most surprising works of the insect kingdom. The wax is secreted, by the peculiar organisation of the insect, in the form of small and thin oval scales, in the incisures or folds of the abdomen. The regular structure of the comb is also equally wonderful.

The comb is composed of a number of cells, most of them exactly hexagonal, constructed with geometrical accuracy, and arranged in two layers, placed end to end, the openings of the different layers being in opposite directions. The comb is placed vertically; the cells, therefore, are horizontal. The distance of the different cakes of comb from each other is sufficient for two bees to pass readily between them, and they are here and there pierced with passages, affording a communication between all parts of the hive. The construction of the cells is such as to afford the greatest possible number in a given space, with the least possible expenditure of material. The base of each cell is composed of three rhomboidal pieces, placed so as to form a pyramidal concavity. Thus the base of a cell on one side of the comb is composed of part of the bases of three on the other. The angles of the base are found, by the most accurate geometrical calculation, to be those by which the least possible expense was required to produce a given degree of strength. The sides of the cells are all much thinner than the finest paper; and yet they are so strengthened by their disposition, that they are able to resist all the motions of the bee within them.

HONG MERCHANTS; a body of from eight to twelve Chinese merchants at Canton, who alone have the privilege of trading with Europeans, and are responsible for the conduct of the Europeans with whom they deal.

HOOPING-COUGH; a disease known by a convulsive, strangulating cough, with hooping, returning by fits, which are usually terminated by a vomiting. It is contagious. Children are most commonly the subjects of this disease, and it seems to depend on a specific contagion, which affects them but once in their life. The disease being once produced, the fits of coughing are often repeated without any evident cause; but, in many cases, the contagion may be considered as only giving the predisposition, and the frequency of the fits may depend upon various exciting causes, such as violent exercise, a full meal, the having taken food of difficult digestion, and irritation of the lungs by dust, smoke, or disagreeable odours. Emotions of the mind may likewise prove an exciting cause. Its proximate or immediate cause seems to be a viscid matter or phlegm lodged about the bronchia, trachea, and fauces, which adheres so closely as to be expectorated with the greatest difficulty.

The hooping-cough usually comes on with a difficulty of breathing, some degree of thirst, a quick pulse, and other slight febrile symptoms, which are succeeded by a hoarseness, cough, and difficulty of expectoration. These symptoms continue, perhaps, for a fortnight or more, at the end of which time the disease puts on its peculiar and characteristic form, and is now evident, as the cough becomes convulsive, and is attended with a sound, which has been called a *hoop*. The coughing continues till either a quantity of mucus is thrown up from the lungs, or the contents of the stomach are evacuated by vomiting. On the first coming on of the disease, there is little or no expectoration; or, if any, it consists only of thin mucus; and, as long as this is the case, the fits of coughing are frequent and of considerable duration; but, on the expectoration becoming free and copious, the fits of coughing are less frequent, as well as of shorter duration. The disease, having arrived at its height, usually continues for some weeks longer, and at length goes off gradually. In some cases, it is however, protracted for several months, or even a year. It is seldom fatal, except to very young children, who are always likely to suffer more from it than those of a more advanced age. The danger seems, indeed, always to be in proportion to the youth of the person, and the degree of fever and difficulty of breathing which accompanies the disease, as likewise the state of debility which prevails.

HOPS. The mode of cultivating this plant will be found in our division devoted to NATURAL HISTORY. The fruit is a sort of cone, composed of membranous scales, each of which envelopes a single seed. These cones are the object for which it is so extensively cultivated, and their principal use is to communicate to beer its strength and their agreeably aromatic bitter. The young shoots, however, are sometimes boiled and eaten like asparagus; the fibres of the old stems make good cords; and it is, besides, employed in medicine as a tonic, sudorific, and sedative. The cultivation of the hop is more carefully attended to in England than in any other country. A light and somewhat substantial soil should be selected. The time of planting is in the autumn, and that of harvesting about six weeks or two months after the flowers are expanded; if the fruit is suffered to get too ripe, it loses many of its good qualities. Other low plants may be cultivated in the intervals between the hop-poles. The hops, on being gathered, should be taken immediately to the kiln for drying, and afterwards packed in bags, the closer the better will they preserve their smell and flavour. The whole process, from the time of planting to the preparation for the purposes of commerce, requires much experience and many precautions. The crops are excessively variable, often in a ten-fold proportion in different seasons and situations. The excellence of hops is tested by the clammy feeling of the powder contained in the cones.

HORARY, or HOUR CIRCLE OF A GLOBE, is a small brazen circle, fixed upon the brazen meridian, divided into twenty-four hours, having an index movable round the axis of the globe, which, upon turning the globe 15°, will show what places have the sun an hour before or after us.

Horary Circles or Lines, in dialling, are the lines or circles which mark the hour on sun-dials.

Horary Motion of the Earth; the arch it describes in the space of an hour, which is nearly 15°, though not accurately so, as the earth moves with different velocities.

HORIZON; the line that seems to link the land or sea and sky, and it is either *rational* or *sensible*. The *rational, true*, or *astronomical* horizon, which is also called simply and absolutely *the horizon*, is a great circle, whose plane passes through the centre of the earth, and whose poles are the zenith and nadir. It divides the sphere into two equal parts or hemispheres. The *sensible, visible*, or *apparent* horizon is a lesser circle of the sphere, which divides the visible part of the sphere from the invisible. Its poles are likewise the zenith and nadir; and, consequently, the sensible horizon is parallel to the rational, and it is cut at right angles, and into two equal parts, by the vertical. These two horizons, though distant from each other by the semi-diameter of the earth, will appear to coincide when continued to the sphere of the fixed stars, because the earth, compared with this sphere, is but a point. The sensible horizon is divided into eastern and western. The

eastern horizon is that part of the horizon wherein the heavenly bodies rise. The *western* horizon is that wherein the stars set. By *sensible horizon* is also frequently meant a circle which determines the segment of the surface of the earth, over which the eye can reach, called also the *physical horizon*. In this sense we say, "a *spacious horizon*, a *narrow, scanty horizon*." It is manifest that the higher the spectator is raised above the earth the farther this visible horizon will extend. On account of the refraction of the atmosphere, distant objects on the horizon appear higher than they really are, or appear less depressed below the true horizon, and may be seen at a greater distance, especially on the sea. Legendre says that, from several experiments, he is induced to allow for refraction a fourteenth part of the distance of the place observed, expressed in degrees and minutes of a great circle. Thus, if the distance be 14,000 toises, the refraction will be 1000 toises, equal to the fifty-seventh part of a degree, or 1′ 3″.

Horizon of a Globe; the broad, wooden, circular ring on which the globe is fixed. On this are several concentric circles, which contain the months and days of the year, the corresponding signs and degrees of the ecliptic, and the thirty-two points of the compass.

Horn, in *physiology;* a tough, flexible, semi-transparent substance. The hollow horns of the ox, goat, &c., the hoof, the horny claw and nail, and the scale of certain animals, as the shell of the tortoise, resemble each other in chemical characters; but they differ very widely from stag's horn, ivory, &c. Horn is distinguished from bone in being softened very completely by heat, either applied immediately or through the medium of water, so as to be readily bent to any shape, and to adhere to other pieces of horn in the same state. It contains but a small portion of gelatine, and in this it differs from bone, which contains a great deal.

Horn consists chiefly of condensed albumen, combined with a small and varying portion of gelatine, with a small part of phosphate of line. The fixed alkalies readily and totally dissolve horn into a yellow saponaceous liquor. With some animals, the horn is an instrument of defence; with others, not. In some species of animals, the males only have horns; as, for instance, the stag. Female sheep seldom have horns. The female goats have horns, but they are always smaller than those of the male. In cattle, the horn is particularly developed. The bull generally has a shorter, denser, firmer horn than the cow. There are, however, hornless cattle. In the case of most horned animals, the horns are not entirely developed until they have become capable of continuing their species.

Horns admit of being divided into at least four kinds: 1. those of the rhinoceros; 2. of the ox, antelope, goat, and sheep; 3. of the camelopard or giraffe; 4. of the deer kind. The horns of the rhinoceros are composed entirely of a horny substance. They are situated not upon the *os frontis*, but on the nasal bones, and are attached to the skull only at the surface of their basis. They appear to be composed of a number of fibres, resembling strong hairs, consolidated together. They are not deciduous, but increase from the root or base in proportion as they wear. Those of the second sort are most common. They belong to many of the ruminating quadrupeds, and some birds have similar processes on their heads. They consist of three parts—an osseous substance, a vascular investment, and the external sheath. The bone is first formed. It appears as a knob, covered with skin, and movable on the *os frontis*. As it elongates, the skin becomes callous, and appears to wear off, when the osseous process is found to be clothed in a real case of horn. It then becomes fixed to the *os frontis* by anchylosis. The horny case grows from the roots, and the increase in each year is marked by a circular groove near the root of the horn. The third sort are the short, straight processes on the head of the camelopard, which are a porous bone, united to the *os frontis* by anchylosis, and terminating in a convex knob; the stem is covered with the skin, but the bulb on the end sustains a number of short, strong hairs, analogous to the fibres composing the horns of the rhinoceros. Those of the fourth kind are peculiar to the deer genus. They are composed entirely of bone, and are shed and reproduced annually. They first appear like two small knobs under the skin. These develope their different branches in succession, still covered with the skin, and a delicate soft hair, forming together what has been called their *velvet coat*, which is extremely vascular. When the horn is completely formed, the velvet coat becomes insensible and dry, and is rubbed off by the deer. The horns of the deer appear to be entirely analogous to the osseous parts of the horns of the other ruminant quadrupeds. The horns of the rhinoceros, and those of the deer, are the two extremes in these organs: the one wants the osseous basis, the other the horny covering. Those of the camelopard and ox exhibit examples of the intermediate structure. Instances are given of horses, cats, and particularly hares, found with horns, but they want confirmation. The human body sometimes produces horny protuberances on various parts.

The horns of animals, literally speaking, formed the most ancient drinking cups. Pindar, Æschylus, and Xenophon make mention of them as being appropriated to this purpose. Philip of Macedon is said to have made use of one. It is from this ancient usage that the general name of *horns* has been given to a species of drinking cup, as, after the actual employment of the animal substance had been discontinued, the shape remained in use. The horns of victims sacrificed to the gods were gilt, and suspended in the temples, more especially in those of Apollo and Diana. From the most remote times, the altars of the heathen divinities were likewise embellished with horns, and such as fled thither to seek an asylum embraced them. Originally the horns were doubtless symbolical of power and dignity, since they are the principal feature of gracefulness in some animals, and the only instrument of defence in others. Hence these ornaments have been frequently bestowed on pictorial representations of gods and heroes; ancient medals frequently present the figures of Serapis, of Ammon, of Bacchus, and of Isis, with these additions. The kings of Macedon were actually in the habit of wearing the horns of a ram in their casques, and the same thing is asserted of various other princes and chieftains.

There is a new patent process for manufacturing articles of horn which must not be passed over without a particular notice. The patentee, in his specification, describes the precise mode of making

rings for bell-pulls; knife and fork handles; the knobs for drawers, and knobs or pins for other articles of furniture.

In making a ring of horn, the required piece is to be first cut out of the flat horn, of its proper dimensions, and nearly in the shape of a horse-shoe; it is then pressed in a pair of dies to give its surface the desired pattern, but, previous to pressing, both the piece of horn and the dies are to he heated; the piece of horn is to be introduced between the dies, and pressed in a vice, and, when cold, the impression or pattern will be fixed upon the horn.

One particular feature, however, is to be observed in the construction of the dies for forming a ring. They are to be so made that the open ends of the horse-shoe piece of horn, after being pressed, shall have at one end a nib and at the other a recess, of a dove-tailed form, corresponding to each other; and the second operation in forming this ring of horn is to heat it, and place it in another pair of dies, which shall bring its open ends together, and cause the dove-tailed joints to be locked fast into each other, which completes the ring, and leaves no appearance of the junction..

In forming the handles of table-knives and forks, or other things which require to be made of two pieces, each of the two pieces or sides of the handle is formed in a separate pair of dies: the one piece is made with a counter-sunk groove along each side, and the other piece with corresponding leaves or projecting edges. When these two pieces are formed, by first being cut out of the flat horn, and then pressed in the dies in a heated state, for the purpose of giving the pattern, the two pieces are again heated and put together, the leaves or edges of the one piece dropping into the counter-sunk grooves of the other piece; and, being introduced between another pair of heated dies, the joints are pressed together, and the two pieces formed into one handle.

In making the knobs for drawers which have metal stems or pins to fasten them into the furniture, the face of the knob is to be first made to a die, as above described, and then the back part of the knob with a hole in it; a metal disc of plate-iron is then provided, in which the metal stem or screw-pin is fixed, and the stem being passed through the aperture in the back piece, and the two—that is, the back and front pieces of horn—put together, they are then heated and pressed in dies as above described, the edge of the back piece falling into the counter-sunk groove of the front piece; and by the heat they are perfectly cemented together.

Horn, or Bugle-Horn; a wind instrument, used chiefly in hunting, to animate the chase and call the dogs together. The hunting horn was formerly flexible, whence the old phrase to "wind a horn."

Horn, French. The French horn, or *cor de chasse*, is a wind instrument, consisting of a long tube twisted into several circular folds, and gradually increasing in diameter from the end at which it is blown to that at which the sound issues. The intervals of the natural scale of the French horn are conformable to those of the trumpet, but its pitch is an octave lower. In order to produce tones which the horn does not otherwise yield, the performer puts his hand into the horn, so as to prevent, more or less, the egress of the air. The Germans have done most for the horn, and by their inventions of valve-horns, and even machine horns, have carried this instrument to much perfection. The horn is not proper for the expression of the grand, but the tender and plaintive. Nevertheless, in Germany, some of the rifle regiments have only horn music, which sounds very finely; and a Russian horn band of more than twenty instruments have lately exhibited their peculiar powers in our own metropolis.

Hornblende, or Amphibole, is one of the most abundant and widely-diffused substances in the mineral kingdom, next to quartz, feldspar, and mica, and is very remarkable on account of the various forms and compositions of its crystals and crystalline particles, and of its exceedingly diversified colours, thus giving rise to almost numberless varieties, many of which have obtained distinct appellations. The primitive form of the species is an oblique rhombic prism of 124° 30′ and 55° 30′, in which the terminal planes are inclined to the obtuse lateral edges, under angles of 105° and 75°. The former planes are easily developed, by cleavage from its crystals and crystalline masses; but the latter have never been obtained in this way, having been inferred from calculation. See Natural History.

Horology. See Watch and Clock Making.

Horoscope; a scheme or figure of the position of the heavens at any time. The heavens were divided by astrologers, for this purpose, into twelve parts, called *houses*, to each of which was assigned its particular virtue or influence. The ascendant was that part of the heavens which was rising in the east at the moment; this is the first house, or house of life, and contained the five degrees immediately above the horizon and the twenty-five beneath it; the second was the house of riches, &c.; the seventh, or angle of the west, the house of marriage; the eighth, the house of death.

Horse Power, in *mechanics*. A horse's power of draught or carriage of course diminishes as his speed increases. The proportion which it bears, according to Professor Leslie, is as follows:—If we represent his force when moving at the rate of two miles an hour by the number 100, his force at three miles per hour will be eighty-one; at four miles, sixty-four; at five miles, forty-nine; at six miles, thirty-six; which results agree pretty nearly with the observations of Mr. Wood (*Treatise on Rail-Roads*). At his height of speed, of course, he can carry only his own weight. A horse draws to the greatest advantage when the line of draught inclines a little upwards. Desaguliers and Smeaton consider the force of one horse equal to that of five men, but writers differ on this subject. The measure of a horse's power, as the standard of the power of machinery, given by Mr. Watt, is, that he can raise a weight of 33,000 lbs. to the height of one foot in a minute. Care should be taken, when a horse draws in a mill, or an engine of any kind in which he moves in a circle, that the circle be large; for, since he pulls obliquely, and advances sideways as well as forwards, his fatigue is greater as the circle is smaller. In some paddle-boats, and machinery, horses are placed on a revolving platform, which passes backward by the pressure of their feet, as they pull forward against a fixed resistance, so that they propel the machinery without moving from their place. A horse may act within still narrower limits, if he stand on the circumference of a large vertical wheel, or on a bridge supported by endless chains, which pass round two

drums, and are otherwise supported by friction-wheels. Various other modes of applying the force of animals are practised, but most of them are attended with great loss of power, either from friction or from the unfavourable position of the animal.

HORSEMANSHIP. The earliest writer on this subject whose work has come down to us is Xenophon. He gives rules for judging of horses, dressing them, and riding. The Romans have left us no work on the manege; and though the mounted hordes who overthrew the Roman empire, and the knights of the later periods of chivalry, must have been skilled in the care and guidance of the horse, the earliest modern treatise on horsemanship was written in the 16th century, by Grisone, an Italian. "There are," says a French writer, "three principal European races, the Latin, the Teutonic, and the Sclavonic, each of which is no less characterized by its manner of riding on horseback than by its language. The Poles and Hungarians, however, who belong to the Sclavonic race, have adopted the Teutonic manner; but the three Latin nations—the French, Italians, and Spaniards—are all of the Italian school." The English, according to this very erudite division, belong to the Teutonic school; and, among "the noble and royal authors" of Walpole, the Duke of Newcastle appears as the author of two treatises, which later writers have done little more than copy or abridge. The principal matters in which the pupil is to be instructed at the manege are, to sit on horseback with firmness, ease, and gracefulness, and to guide his horse accurately in going straight forward, to the right or left, or sideways, at a walk, trot, or gallop, to halt at once, and to rein back without difficulty. In mounting, the rider approaches the horse near the left shoulder, and, grasping the reins firmly, takes a handful of the mane in his bridle-hand, puts the left foot into the stirrup, and, raising himself up, passes the right leg clear over the saddle. The reins must not be taken too short, lest it should make the horse rear, run or fall back; but they ought to be of equal length, and neither tight nor slack. The rider should be placed upright in the saddle, with the body rather back, and the head held up with ease, but without stiffness. The breast should be pushed out a little; the thighs and legs turned in without restraint, so that the fore part of the inside of the knees may press on the saddle, and the legs hang down easily and naturally, the feet being parallel to the horse's sides, neither turned in nor out, but so that the toes should be kept a little higher than the heels.

By this position, the natural weight of the thighs has a proper and sufficient pressure of itself, and the legs are in readiness to act when necessary. For this purpose, they should always be near the horse's sides, but without touching or tickling them. The body must be kept easy and firm when in motion; the left elbow should lean gently against the body, a little forward, and the hand, in general, should be of about the same height as the elbow; the right arm must be placed in symmetry with the left, only let the right hand be a little more forward or backward, as occasion may require. The left hand, which holds the reins, must be kept clear of the body, about two inches and a half forward from it, and immediately above the pommel of the saddle; the nails should be turned towards the buttons of the waistcoat, and the wrist a little rounded with ease, the joint being kept easy and pliable, yielding and taking occasionally, as necessary.

A firm and well-balanced position of the body is of the utmost consequence, as it affects the horse in every motion. The body must always go along with the horse, and the leaning, therefore, should be towards that side to which he moves. It is requisite, in horsemanship, that the hand and legs should act in correspondence with each other in every thing, the latter being always subservient to the former. Upon circles, the outward leg (the one from the centre) is the only one to be used, and that only for a moment at a time, to make the horse go true, if he be false. If the horse be lazy, or in any way retain himself, both legs must be used, and pressed to his sides at the same time. In general, however, the less the legs are used the better. In reining back, the rider should be careful not to use his legs, unless the horse backs his shoulders, in which case they must both be applied gently, at the same time, and correspond with the hand. If the horse refuse to back at all, the legs must be gently approached, until he lift up a leg as if to go forward, when the rein of the same side with the lifted leg will easily bring him backward. If he attempt to rear, the legs must be instantly removed and the reins slackened.

HORTICULTURE includes, in its most extensive signification, the cultivation of esculent vegetables, fruits, and ornamental plants, and the formation and management of rural scenery for the purposes of utility and embellishment. The classification of the vegetable kingdom, as well as the description and particular treatment of plants individually, belongs to another division of this work; we shall, therefore, in the present article, apply ourselves to the history of *horticulture* only as it is connected with general science. The earliest effort of man to emerge from a state of barbarism was directed to the tillage of the earth: the first seed which he planted was the first act of civilization, and gardening was the first step in the career of refinement; but still it is an art in which he last reaches perfection.

When the savage exchanges the wild and wandering life of a warrior and hunter for the confined and peaceful pursuits of a planter, the harvests, herds, and flocks, take the place of the simple garden. The mechanic arts are next developed; then commerce commences, and manufactures soon succeed. As wealth increases, ambition manifests itself in the splendour of apparel, of mansions, equipages, and entertainments. Science, literature, and the fine arts are unfolded, and a high degree of civilization is attained. It is not until all this has taken place that horticulture is cultivated as one of the ornamental arts. Egypt, the cradle of civilization, so far perfected her tillage that the banks of the Nile were adorned by a succession of luxuriant plantations, from the cataract of Syene to the shores of the Delta; but it was when Thebes, with its hundred brazen gates, and the cities of Memphis and Heliopolis, were rising in magnificence, and her stupendous pyramids, obelisks, and temples, became the wonders of the world.

The hills and plains of Palestine were celebrated for beautiful gardens; but it was not until the walls and temple of Jerusalem announced the power and intelligence of the Israelites, and the prophets had rebuked their luxury and extravagance. The queen of the East "had heard of the fame of Solomon;" his fleets had brought him the gold of Ophir, and the

treasures of Asia and Africa; the kings of Tyre and Arabia were his tributaries, and princes his merchants, when he "made orchards," "delighted to dwell in gardens," and planted the "vineyard of Baalhaman." The Assyrians had peopled the borders of the Tigris and Euphrates, from the Persian Gulf to the mountainous regions of Ararat, and their monarchs had founded Nineveh and Babylon, before we hear of the gardens of Semiramis. The Persian empire had extended from the Indus to the Archipelago, when the paradise of Sardis excited the astonishment of a Spartan general, and Cyrus mustered the Grecian auxiliaries in the spacious garden of Celænæ. The Greeks had repulsed the invasions of Darius and Xerxes, and Athens had reached the height of her glory, when Cimon established the Academus, and presented it to his fellow citizens as a public garden. Numerous others were soon planted, and decorated with temples, porticoes, altars, statues, and triumphal monuments; but this was during the polished age of Pericles, when Socrates and Plato taught philosophy in the sacred groves—when the theatre was thronged to listen to the poetry of Euripides and Aristophanes—when the genius of Phidias was displayed in rearing the Parthenon and sculpturing the statues of the gods—when eloquence and painting had reached perfection, and history was illustrated by Herodotus, Thucydides, and Xenophon. Rome had subjugated the world, and emulated Athens in literature, science, and the arts, when the superb villas of Sallust, Crassus, Pompey, Cæsar, Mæcenas, and Agrippina were erected, and the palaces of the emperors were environed by magnificent gardens.

The history of modern nations presents similar results. Horticulture long lingered in the rear of other pursuits. Most of the common fruits, flowers, and vegetables which had been collected by the Greeks and Romans, from Egypt, Asia, and other distant climes, were successively extended over Western Europe; but so gradual was their progress, after the dark ages, that, till the reign of Henry VIII., scarcely any kitchen vegetables were cultivated in England, and the small quantity consumed was imported from Holland. Fuller observes that "gardening was first brought into England for profit, about the commencement of the seventeenth century. Peaches, nectarines, apricots, plums, pears, cherries, strawberries, melons, and grapes, were luxuries but little enjoyed before the time of Charles II., who introduced French gardening at Hampton Court, Carlton, and Marlborough, and built the first hot and ice houses. At this period Evelyn translated the *Complete Gardener*, and a treatise on orange trees, by Quintinyne; and, having devoted the remainder of his life to the cultivation of his rural seat at Sayes Court, near Deptford, and the publication of his *Sylva*, *Terra*, *Pomona*, and *Acetaria*, he "first taught gardening to speak proper English." In the Netherlands, France, Germany, and Italy, a formal and very imperfect system of gardening was practised, with considerable success; but it was generally in a languishing condition throughout the world, until the commencement of the eighteenth century, when it attracted the attention of some of the first characters of Great Britain; but the establishment of the present improved style of horticulture is of very recent date. "Bacon was the prophet, Milton the herald, and Addison, Pope, and Kent the champions of true taste." The principles which were developed in their writings, and those of Shenstone, the Masons, and Wheatly, were successfully applied by Bridgeman, Wright, Brown, and Eames; the system soon became popular, and gradually extended over Europe.

But the labours of the London Horticultural Society have mainly contributed to the perfection and present high estimation of gardening. That noble institution has given an impetus to cultivation, which is felt in the remotest countries. Its example has been followed in the most flourishing kingdoms of the eastern continent, and many similar institutions have been founded in the United States of America. The effect of these is to diffuse through every country the knowledge and products of all. The history, literature, and science of gardening, open a wide field for study and inquiry. The pleasure which gardens afforded men, even in the earliest times, appears from the scriptural account of the garden of Eden. The garden of Gethsemane, and that of the good and just Arimathean, are memorable in the sacred history of the Messiah. The Elysian fields were the heaven of classic mythology, and the devout Mussulman hopes to renew his existence in a celestial garden. The bards, scholars, and philosophers of the classic ages, have transmitted descriptions of the gardens of the ancients, from those in which Homer places the palace of Alcinous and the cottage of Laertes, to the splendid villas of Pliny and Lucullus. Among the ancient Greek writers, Hesiod, Theophrastus, Xenophon, and Ælian treated of gardens to a certain extent; and the works of those who wrote after the seat of government was removed to Constantinople were collected under the title of *Geoponica*, and have been translated by Owen. Among the Latins, Varro was the first author, to whom succeeded Cato, Pliny the Elder, Columella, and Palladius. Passages are to be found relative to the subject in Martial, Virgil, and Horace; but Pliny's *Natural History*, and Columella's book on gardens, contain the most correct information on Roman horticulture.

Literature and the arts having revived in Italy, that country was the first to produce books on agriculture and gardening, and that of Crescenzia became celebrated. The field and garden cultures of Italy are so nearly allied, and horticulture and agriculture have been so blended by the writers, that is difficult to ascertain under which department to include their works. The best for general information on the tillage of that delightful region is the *Annali dell' Agricoltura*. The Germans, as in all the branches of letters, science, and arts, have an immense number of books in the department of gardening, especially on the subject of planting and forest trees. The Dutch excel more in the practice than the literature of gardening. The Journal of a *Horticultural Tour* in Holland and Flanders, by a deputation of the Caledonian Horticultural Society, gives the most satisfactory account of gardening in that part of the continent, in 1817. The *Transactions* of the Stockholm and Upsal academies furnish the chief information which is to be obtained in relation to the rural economy of Sweden. The first author was Rudbeck, who was a contemporary of Commelin.

Russia and Poland have produced but very few original books on horticulture. The *Agricultural Transactions*, occasionally published by a society in Warsaw, with those of the Economical Society of St. Petersburg, may be considered as affording the most accurate intelligence as to the culture of those countries. In the latter city is an extensive imperial

botanical garden, which, being under the direction of able professors, emulates those of the more favoured portions of southern Europe. The only recorded information on the subject of Spanish tillage will be found in the *Transactions* of the Royal Agricultural Society of Madrid. The horticultural literature of France is of an early date, and the authors are not only numerous, but many of them in the highest repute. Etienne and Belon were the pioneers, while Du Hamel, Girardin, D'Argenville, Rosier, Tessier, Calvel, Noisette, Du Petit Thours, Jean and Gabriel Thouin, Bosc, and Vicomte Hericart de Thury, may be considered as among the most able of their followers, in the various branches of rural economy. For a general knowledge of French culture, the *Nouveau Cours d'Agriculture*, in thirteen volumes, published in 1810, should be consulted; but the most valuable publications on the existing mode of gardening are the *Annales de la Société d' Horticulture*, the *Annales de l'Institut Royal Horticole de Framont*, and the *Bon Jardinier*. The first English treatise on rural economy was Fitzherbert's *Book of Husbandry*, which was published in 1634. The works of Tusser, Googe, and Platt soon after appeared, and, early in the eighteenth century, the celebrated treatise of Jethro Tull excited much attention, and several new works of considerable merit were announced before 1764, when the valuable publications of Arthur Young, Marshal, and numerous other authors, spread a knowledge of cultivation, and cherished a taste for rural improvements throughout Great Britain. Thus the literature of horticulture rapidly advanced; but, as many of the most eminent writers have been named in treating of the science and art of GARDENING, it is unnecessary to mention them in this place.

The scientific relations of horticulture are numerous, and require an extensive acquaintance with the various branches of natural history and physics. Botany, mineralogy, chemistry, hydraulics, architecture, and mechanics, must furnish their several contributions, which it is the province of the artist to apply.

After the illustrious Linnæus published his *System of Nature*, botany became a popular science, and a variety of interesting elementary works awakened attention to the beauties of nature, so that a passion for experimental and ornamental planting was induced, which has been productive of great results. Mineralogy enables us to obtain an accurate knowledge of terrestrial substances, and the mode of distinguishing the divers kinds of earths which constitute a good soil; and chemistry instructs us as to the nature and properties of these various earths, having for its objects, when applied to horticulture, all those changes in the arrangements of matter which are connected with the growth and nourishment of plants, the comparative value of their produce as food, the constitution of soils, and the manner in which lands are enriched by manure, or rendered fertile by the different processes of cultivation. Inquiries of such a nature cannot but be interesting and important, both to the theoretical horticulturist and the practical gardener. To the first they are necessary in applying most of the fundamental principles on which the theory of the art depends. To the second they are useful in affording simple and easy experiments for directing his labours, and for enabling him to pursue a certain and systematic plan of improvement.

To hydraulics belong, not only the conducting and raising of water, with the construction of pumps and other engines for those purposes, but the laws which explain the nature of springs and fountains. By the principles of that science, artificial lakes, canals, and aqueducts are formed, irrigations projected, and water rendered subservient to the useful purposes of life, as well as to the embellishment of pleasure-grounds by *jets d'eau*, cascades, and streams.

Architecture, as a branch of horticulture, is of the first importance. Without its aid, it would be impossible to give that propriety and elegance to the scenery, and to produce that pleasing effect, which is the chief object of landscape gardening. Mechanics, in all its branches, is required for the purposes of horticulture. Great improvements have been effected in gardening within the last half century. During the age of Cicero, a formal kind of gardening prevailed, characterized by clipped hedges and long avenues of trees. Pliny the Younger has given an account of his villa at Laurentum, and, judging from the description, it was rather distinguished for its numerous superb edifices, extensive prospects, and the systematical arrangement of the pleasure grounds, than for the improvements and decorations of the surrounding scenery, in accordance with those principles which are derived from a close observance of the pleasing effects of nature. The rural residences of the Romans appear to have been mere places of temporary retreat; they were planted with odoriferous flowers and shrubs, and ornamented rather by the civil architect than the horticultural artist. From the establishment of the papal government to the commencement of the thirteenth century, the monks were the only class of persons who attended to ornamental gardening.

After that period, the style prevalent throughout Europe consisted in tall hedges, square parterres fantastically planted, straight walks, and rows of trees uniformly placed and pruned. In fact, but little improvement was made from the time of the emperors Vespasian and Titus until the beginning of the reign of George III. It is true, Hampton Court had been laid out by Cardinal Wolsey; Le Nôtre had planted Greenwich and St. James's Park during the reign of Charles II.; and, in that of George II., Queen Caroline had enlarged Kensington Gardens, and formed the Serpentine River; but Lord Bathurst was the first who deviated from straight lines, as applied to ornamental pieces of water, by following the natural courses of a valley. Still, what has been emphatically called the *Dutch system* universally prevailed: the shearing of yew, box, and holly into formal figures of various kinds, and the shaving of river banks into regular slopes, went on until their absurdity became contemptible, and a better and more natural taste was induced.

Verdant sculpture, regular precision in the distribution of compartments, and rectangular boundary walls, yielded to more chaste designs. Bridgeman succeeded to Loudon and Wise, and became a distinguished artist; he rejected many of the absurd notions of his predecessors, and enlarged the bounds of horticulture. Other innovators departed from the rigid rules of symmetry; but it was reserved for Kent to realize the beautiful descriptions of the poets, and carry the ideas of Milton, Pope, Addison, and Mason more extensively into execution. According to Lord Walpole, he was painter enough to taste the charms of landscape, sufficiently bold and opinionative to dare and to dictate, and born with a genius to strike out a great system from the twilight of im-

perfect essays. He leaped the fence, and saw that all nature was a garden. The great principles on which he worked were perspective, light, and shade. Groups of trees broke a too extensive lawn; evergreens and wood were opposed to the glare of the champaign, and by selecting favourite objects, and veiling deformities, he realized the compositions of the great masters in painting. Where objects were wanting to animate his horizon, his taste as an architect could immediately produce them. His buildings, his temples, his seats, were more the work of his pencil than of his science as a constructor. He bade adieu to all the stiff modes of canals, circular basins, and cascades tumbling over marble steps. Dealing in none but the true colours of nature, and seizing upon its most interesting features, a new creation was gradually presented. The living landscape was chastened or polished, not transformed.

The elegant works of Repton, the unrivalled essays of Price on the picturesque, and the valuable publications of Gilpin, Madock, Panty, Sang, and Loudon, with those of many other writers on landscape and ornamental gardening, have had an extensive influence in promoting correct ideas of natural scenery. The improved style of horticulture every where apparent in Great Britain attracted the attention of the other nations of Europe, and English gardening became the designation for all that was beautiful in that pleasing art—the synonyme of perfection in rural culture. At the period when this new system of laying out grounds was gaining converts, and began to be practically adopted, Viscount Girardin, a French military officer of high rank, travelled through England, and, on his return, he not only improved his seat at Ermenonville in conformity to that style, but published a work of great celebrity on the *Composition des Paysages sur le Terrain, ou des Moyens d'embellir la Nature près des Habitations.*

The French style of laying out gardens had been settled by Le Nôtre, during the reign of Louis XIV., and continued in repute for upwards of a century; for it appears to have been in vogue as late as 1770. The court and nation wished to be dazzled by novelty and singularity, and his long, clipped alleys, triumphal arches, richly decorated parterres—his fountains and cascades, with their grotesque and strange ornaments—his groves full of architecture and gilt trellisses—and his profusion of statues, enchanted every class of observers. His principal works were the gardens of Versailles, Meudon, St. Cloud, Sceaux, Chantilly, and the terrace of St. Germain. Gray, the poet, was struck with their splendour when filled with company, and when the water-works were in full action; but Lord Kaimes says, they would tempt one to believe that nature was below the notice of a great monarch. Le Nôtre was succeeded by Dufresny, who, differing considerably in taste from that great artist, determined on inventing a more picturesque style: but his suggestions were rarely carried into full execution. He, however, constructed, in a manner superior to his predecessor, the gardens of Abbé Pajot and those of Moulon and Chemin Creux.

After the peace of 1762, the English system began to pass into France, and portions of ancient gardens were destroyed, to make way for young plantations *à l'Anglaise*. Laugier was the first author who espoused the English style, and the next in order was Prevot. It was at this time that Viscount Girardin commenced his improvements at Ermenonville, and the change of the horticultural taste in France may be referred to the last quarter of the eighteenth century. The English style has gradually found its way into most civilized countries. A horticultural society was established in Paris in 1826, and has already more than two thousand members, and the number is rapidly increasing. It has been patronised by the court, and most of the nobles and men of distinction in France have eagerly united with the proprietors of estates and practical cultivators to collect and disseminate intelligence throughout that flourishing empire.

In the various provinces where horticultural societies have not been founded, those of agriculture, or of the sciences and arts, have established departments expressly devoted to that interesting pursuit; and during the year 1827 a practical and theoretical institution was founded at Fromont, by the enlightened and munificent Chevalier Soulange Bodin, for educating gardeners, and introducing improvements in every department of horticulture. The garden is divided into compartments for every variety of culture. Extensive green-houses, stoves, and orangeries have been erected, and all the other appendages furnished which are requisite for rendering the establishment effectual for instruction and experiment. The nursery of the Luxembourg long supplied a great part of Europe with fruit-trees.

The *Jardin des Plantes*, in Paris, includes compartments which may be considered as schools for horticulture, planting, agriculture, medical botany, and general economy, and is unquestionably the most scientific and best managed establishment in Europe. The flower garden of Malmaison, the botanical garden of Trianon, and numerous nursery, herb, medicinal, experimental, and botanical gardens, in various parts of the kingdom, are pre-eminent for the variety, number, and excellence of their products.

Holland has been distinguished, since the period of the crusades, for her flower-gardens, culinary vegetables, and plantations of fruit trees. The north of Europe and the United States of America are still dependent upon her florists for the most splendid varieties of bulbous-rooted plants. From St. Petersburg to the shores of the Mediterranean, horticulture has made a rapid progress, and each nation is emulous to perfect its culture, in accordance with the most improved principles of science, art, and taste. In the United States of America, a like spirit has been more recently developed.

Horticultural societies have been instituted in New York, Philadelphia, Boston, Albany, Geneva, and South Carolina, and a zealous disposition evinced to compete with the nations of the eastern continent. The environs of many of the cities are in a high state of cultivation, and the markets are beginning to be well stocked with numerous varieties of fruits and vegetables. Many of the most useful and magnificent acquisitions of the groves, fields, gardens, and conservatories of Europe are natives of the western hemisphere. The indigenous forest trees, ornamental shrubs, flowers, fruits, and edible vegetables of North America, are remarkable for their variety, size, splendour, or value. Extending from the pole to the tropics, and from the Atlantic to the Pacific, North America embraces every clime, and every variety of soil, teeming with innumerable specimens of the vegetable kingdom.

The natural divisions of horticulture are the esculent or kitchen garden, seminary, nursery, fruit-trees, and vines, flower garden, green-houses, *arboretum* of ornamental trees and shrubs, the botanical and medical garden, and landscape or picturesque gardening. Each of these departments requires to be separately studied before it can be managed so as to combine utility and comfort with ornament and recreation. To accomplish this on a large scale, artists, scientific professors, and intelligent and experienced practical superintendents, are employed in Europe, but they have not as yet been much required in America. The owners of the soil have generally designed and executed such improvements as have been made in the conveniences and embellishments of country residences. The kitchen garden is an indispensable appendage to every rural establishment. In its simplest form, it is the nucleus of all others: containing small compartments for the culture of esculent vegetables, fruits, and ornamental plants, these may be gradually extended, until the whole country assumes the imposing aspect of picturesque or landscape scenery.

Among the European productions on horticulture, there is no single work in the English language so valuable as Loudon's *Encyclopædia of Gardening;* but all the numerous publications of that distinguished writer, in the various branches of rural economy, are remarkable for the fund of intelligence which they contain.

HORTUS SICCUS. See NATURAL HISTORY.

HOSPITAL; a building appropriated for the reception of sick, infirm, and helpless persons, who are supported and nursed by charity; also a house for the reception of sick or insane persons, or an establishment for seamen, soldiers, foundlings, &c., who are supported by charity. Hospitals for the sick and wounded, and also those for the poor or infirm, were wholly unknown among the ancients. In Athens, those who had suffered in the public service were fed in the *prytaneum*, but there was no asylum for them in case of sickness. In Sparta, where all the citizens ate together, there was no institution for the sick. In Rome, neither Numa nor Servius, neither the consuls nor the emperors, thought of making any provision for the poor or the infirm. The first establishment of hospitals must be ascribed to Christians; some attempts had already been made by them in Rome, about the end of the fourth century. Fabiola, a pious Roman lady, established an institution for receiving poor and sick persons; and, after the establishment of Christianity, the emperors at Constantinople built many hospitals for poor infants, for aged people, for orphans, for strangers, &c. The Emperor Julian attributed the rapid progress of the Christian religion, in great part, to these charitable institutions, and proposed to imitate the example of the Christians in his attempts to restore paganism. Piety impelled many individuals to appropriate a part of their funds to religious and charitable purposes. Institutions thus formed were of great benefit to the sick poor, but soon became liable to abuses. The funds devoted to charitable purposes were alienated, and the monastic institutions with which they were connected were contaminated with looseness and extravagance.

In Catholic countries, the hospitals are generally attended by nuns, sisters of mercy, &c., of whom even Voltaire says that there is nothing nobler than the sight of delicate females sacrificing beauty, youth, often wealth and rank, to devote themselves to the relief of human miseries, under the most revolting forms. Hospitals are an honour to the nations of Europe. In less civilized countries, we find them to be frightful abodes of misery. The plague hospital at Alexandria, described by Madden, or the insane hospital at Cairo, presents a scene of horrors not inferior to Dante's description of the feverish people, one above the other, in his *Inferno*. If possible, it is best, in infirmaries, to separate certain patients. Thus, in all populous cities there should be an hospital for incurables. It is never advisable to have the insane hospital nor the lying-in hospital connected with others; still less, as is the case in many places in Europe, to connect the workhouses and the hospitals. In Paris there are thirty-two hospitals: in London about the same number. Those in France, Russia, and Turkey, are supported by government.

The name of *hôpital* is generally applied to the establishments for the sick, and that of *hospice* to those in which the aged, children, and infirm people, are received. More than 15,000 beds are made up at these different establishments, and the annual expenditure is very considerable. From 40,000 to 50,000 persons are annually accommodated in *hôpitaux*, or about 4000 at a time. The *hospices* generally contain nearly 10,000 persons at the same time. The hospitals of Paris are usually clean and in good order, for which they are indebted to the *sœurs de la charité*, who wait upon the sick, and nurse them with the greatest care. They are not always favourably situated, being often too much confined.

The *Hôtel des Invalides* is destined for military veterans, and contains 7000 men. It has a library of 20,000 volumes. The *Hôtel Dieu* is the most ancient hospital in Paris, and is situated in the most populous part of the city. Before the revolution, 5000 sick were here huddled together in 1400 beds; but several monasteries were then converted into hospitals, and lying-in women, scrofulous patients, lunatics, children, &c., who had all been crowded together, were separated, and placed in different establishments. The *Hospice de la Salpétrière* generally contains several thousand poor women, who are kept at work. In one part is a prison for prostitutes. The *Hôpital de la Charité* receives only men attacked by acute diseases; the *Hôpital St. Louis* is used as a pest-house; the *Hospice des Enfants Trouvés* is for foundlings, about 6000 of whom are annually born or received in it; the *Hospice de l'Accouchement* receives about 3000 women annually.

Among the hospitals in London and its vicinity are the Foundling Hospital; the Magdalen Hospital, for reclaiming prostitutes; the Greenwich Hospital and Naval Asylum. The Chelsea Hospital is appropriated for the reception of sick and superannuated soldiers; the number of pensioners is about 400, besides the out or extraordinary pensioners. The principal hospitals for the reception of sick persons in the metropolis are St. Thomas's, Guy's, St. Bartholomew's, St. George's, the London, the Westminster, and Middlesex. The whole of these establishments are easy of access, and noble monuments of the real Christian feeling of their founders.

Hospital Fever is a malignant form of fever, which has received this title from its being most frequently met with in places of this sort, especially in military and other large hospitals, where many men are shut

up in a small space and in close air. Under such circumstances, almost any fever will assume a more malignant character, and become more or less contagious. The causes of common hospital fever are to be found in the want of good and wholesome provisions, fatigue, care, and anxiety, and, more especially, the corruption of the air, which is always produced by many men living in even a large building, or by fewer, if shut up in a small space; and these causes are found to produce this effect not only upon the soldier, but upon the poor of all kinds and in all places.

A similar disease is developed among those confined in prisons and ships, and among the inhabitants of damp, narrow huts, and is called *gaol, ship*, or *typhus fever*. The common fever, which often prevails under the last name, has not, indeed, all the characteristics of this form of fever, although it easily assumes them. The *hospital fever* is only a high degree of that form of disease which is usually called a *putrid*, or *putrid nervous fever;* that is, a fever with diminished power and action of the whole nervous system. The contagion produced by hospital, or putrid fever, is capable of producing fever in others, although the fever so produced is often of a different character and appearance; and it should be remarked that it almost ceases to be contagious by a removal to a pure air and well-ventilated apartments.

The form assumed by the disease is much affected by the general state of the weather, and by the constitution of the individual. In strong, young, well-fed, and full-blooded persons, in whom the arterial system is full, and an inflammatory disposition much developed by stimulating drinks, or a dry, cold air, which is very favourable to inflammation, an inflammatory excitement of the whole nervous system takes place, which may even run to the height of an inflammation of the brain, with delirium, &c. In others, who have been much reduced by bad diet, and by exposure to warm, moist weather, a gastric form of fever is developed, attended also with violent nervous symptoms. If it happens to seize persons in whom the nervous and circulatory systems are much debilitated by any of the causes above named, a fever more like the true hospital fever is produced, which is termed a *typhus, putrid*, or *adynamic fever*. In truth we scarcely ever see a form of this fever which is quite unmixed, but all the forms pass into each other, with innumerable shades of accidental difference, arising from difference of the parts most affected, &c. It will therefore be at once evident that no universal mode of treatment can be laid down, but that the treatment must be varied according to the causes of the disease, the state, constitution, and previous habits of the sick, &c., and according to the changes which are constantly occurring in the course of the disease. The most important modes of guarding against the hospital fever are—to remove the causes of it, to purify the air, to improve the nourishment, allowing a generous diet, and to prevent the sick from being accumulated in great numbers in one apartment. The wards or rooms in which they are or have been collected should be purified by the vapours of strong mineral acids, which are easily obtained by mixing common salt with black oxide of manganese in a vessel of any sort, and then stirring into it a portion of oil of vitriol or sulphuric acid. But, above all, the rooms should be well ventilated, and the clothes of all kinds should be changed daily.

HOUR; the twenty-fourth part of a day. In many countries, the hours are counted from midnight, and twelve hours are twice reckoned. But in some parts of Italy twenty-four hours are counted, beginning with sunset, so that noon and midnight are every day at different hours. Each hour is divided into sixty minutes, these into sixty seconds, these into sixty thirds, &c. Many nations are totally unacquainted with the division of the day into twenty-four equal parts; with others, the hours of the (natural) day are longer or shorter than those of the night. (See SIDEREAL TIME.) The fixed stars complete their apparent revolution round the earth in twenty-four hours of sidereal time, and therefore pass through 360 degrees in twenty-four hours, or fifteen degrees in one hour. If we suppose two observers fifteen degrees of longitude distant from each other, one of them has the fixed star one hour of sidereal time, or the sun one hour of solar time, later in his meridian than the other. Meridians are thence called *hour-circles*, or *horary circles*, by which name they are known in dialling. A *horary angle* is that angle which any hour-circle makes with the meridian of the observer. If, for instance, it is 10 o'clock A. M. according to the sun-dial at the place of observation, and the sun is therefore two hours distant from the meridian, its hour-circle makes an angle of 30° with the meridian.

HOWITZER; a piece of ordnance which ranks midway between the cannon and mortar. It is mounted upon a carriage, and throws its grenades in a curve approaching a horizontal line (at the highest 16°). The arrangement of the chamber, and the extensive range of the piece, resemble those of the mortar. The length of the tube amounts to six times the caliber. The howitzer is used to throw grenades, case-shot, and sometimes fire-balls. Its principal object, however, is the discharge of grenades. Troops upon an open plain, who are secure from the fire of cannon, can be reached and injured by the discharge and bursting of grenades. By the same means villages and towns can be set on fire, and garrisons dislodged from their works. Howitzers are of German invention, and bore, originally, the name of *Haufenitz*, when they were loaded with old nails, broken glass, &c. From thence is derived the French *obusier*, and the English *howitzer*.

HUMORAL, in *medicine;* what has relation to the humours or fluids of the system. The humoral pathology is a medical theory which long prevailed, and attributed all diseases to irregular changes in the fluid parts of the body, without assigning any influence to the state of the solids. The opposite theory is that which refers every thing to the nervous energy resident in the solids, and considers diseases as arising from irregularities in their functions. The humoral pathology is exposed, in many ways, to the objection that it rests on hypothesis, and is very partial in its views. The views of the adherents of this theory have differed continually, with the progress of knowledge, from the days of Hippocrates and Galen, its great supporters, down to very late times. The nervous pathology is also liable to the objection of being of a partial and hypothetical character. Of late, the two systems have been blended, and both fluids and solids allowed a share in the changes of the body.

HURRICANE; a violent tempest of wind, attended with thunder and lightning, and rain or hail. Hurricanes appear to have an electric origin: at the mo-

ment that the electric spark produces a combination of oxygen and hydrogen, a sudden fall of rain or hail is thus occasioned, and a vacuum formed, into which the circumambient air rushes with great rapidity from all directions. The West Indies, the Isle of France, and the kingdoms of Siam and China, are the countries most subject to their ravages. What are called hurricanes, in the more northern latitudes, are nothing but strong whirlwinds, occasioned by the meeting of opposite currents. But, in the real hurricane, all the elements seem to have armed themselves for the destruction of human labours, and of nature herself: the velocity of the wind exceeds that of a cannon ball; corn, vines, sugar-canes, forests, houses, every thing is swept away. The hurricane of the temperate zone moves with a velocity of about sixty feet a second; those of the torrid zone, from 150 to 300 feet in the same time. They begin in various ways; sometimes a little black cloud rolls down the mountains, and suddenly unfolds itself and covers the whole horizon; at others, the storm comes on in the shape of a fiery cloud, which suddenly appears in a calm and serene sky.

Hydraulics; that branch of hydrodynamics which has for its object the investigation of the motions of liquids, the means by which they are produced, the laws by which they are regulated, and the force or effect which they exert against themselves or against solid bodies. This subject naturally divides itself into three heads: 1. the effects which take place in the natural flowing of fluids through the various ducts or channels which convey them; 2. the artificial means of producing motion in fluids, and destroying their natural equilibrium by means of pumps and various hydraulic engines and machines; and, 3. the force and power which may be derived from fluids in motion, whether that motion be produced naturally or artificially. The particles of fluids are found to flow over or amongst each other with less friction than over solid substances; and, as each particle is under the influence of gravitation, it follows that no quantity of homogeneous fluid can be in a state of rest, unless every part of its surface is on a level, that is, not a level plane, but so far convex as that every part of the surface may be equally distant from the centre of the earth. As the particles of all liquids gravitate, any vessel containing a liquid will be drawn towards the earth with a power equivalent to the weight it contains, and if the quantity of the fluid be doubled, tripled, &c., the gravitating influence will be doubled, tripled, &c. The pressure of fluids is, therefore, simply as their heights,—a circumstance of great importance in the construction of pumps and engines for raising water. As liquids gravitate independently, if a hole be made in the bottom of the vessel, the liquid will flow out, those particles directly over the hole being discharged first. Their motion causes a momentary vacuum, into which the particles tend to flow from all directions, and thus the whole mass of the water, and not merely the perpendicular column above the orifice, is set in motion. If the liquid fall perpendicularly, its descent will be accelerated in the same manner as that of falling solid bodies. When water flows in a current, as in rivers, it is in consequence of the inclination of the channel, and its motion is referable to that of solids descending an inclined plane; but, from want of cohesion among its particles, the motions are more irregular than those of solids, and involve some difficult questions. The friction between a solid and the surface on which it moves can be accurately ascertained; but this is not the case with liquids, one part of which may be moving rapidly and another slowly, while another is stationary. This is observable in rivers and pipes, where the water in the centre moves with greater rapidity than at the sides, so that a pipe does not discharge as much water in a given time, in proportion to its magnitude, as theoretical calculation would lead us to suppose. As water, in descending, follows the same laws as other falling bodies, its motion will be accelerated; in rivers, therefore, the velocity and quantity discharged at different depths would be as the square roots of those depths, did not the friction against the bottom check the rapidity of the flow. The same law applies to the spouting of water through jets or adjutages. Thus, if a hole be made in the side of a vessel of water, the water at this orifice, which before was only pressed by the simple weight of the perpendicular column above it, will be pressed by the same force as if the water were a solid body descending from the surface to the orifice; that is, as the square root of the distance of these two points; and, in the same way, water issuing from any other orifices, will run in quantities and velocities proportionate to the square root of their depths below the surface. Now, the quantity of water spouting from any hole, in a given time, must be as the velocity with which it flows: if, therefore, the hole *c*, *fig*. 5, *Plate* I., be four times as deep below the surface as a hole, *a*, it follows that *c* will discharge twice as much water in a given time as *a*, because two is the square root of four. A hole, *b*, in the centre of such a column of water will project the water to the greatest horizontal distance (or range), which will be equal to twice the length of the column of which the orifice is the centre. In like manner, two jets of water, spouting from holes at equal distances above and below the central orifice, will be thrown equal horizontal distances. The path of the spouting liquid will always be a parabola, because it is impelled by two forces, the one horizontal, and the other perpendicular.

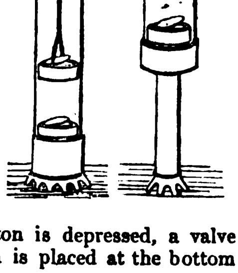
Fountains owe their operation to the weight or pressure of a column of water, and the *jet d'eau* shown at *fig*. 3 acts on this principle. The support of a ball on a simple column of water may be best understood by a reference to *fig*. 4. The ascending column of water carries with it a stream of air, represented by the arrows, which completely encloses the fluid, and the ball has a species of oscillatory balance, continually revolving round the centre of the jet.

Pipes for the conveyance of water are usually arranged on very imperfect principles. It must be obvious that fluids will flow most freely through a straight pipe; but, as there are many cases in which water must be conveyed in an angular direction, the workman should always form the pipe with as large a *sweep* or curve as possible. *Fig*. 6 shows the two forms; *a* being the best, and *b* the worst. It might, at first view, be supposed that the expansion at *c* was advantageous to the passage of the water; but, so far from this being the case, it would be considerably retarded by it, as the pipe should be as nearly straight as possible.

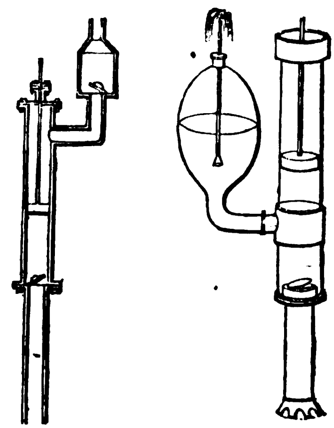
The second division of the subject, mentioned in the beginning of this article, is of the greatest practical utility, as embracing an account of the various pumps and machines which have been employed to

raise water; and, numerous as these may appear, it will be found that they may all be comprehended under four general heads: 1. those machines in which water is lifted in vessels by the application of some mechanical force to them. The earlier hydraulic machines were constructed on this principle, which is the simplest; such as the Persian wheel, consisting of upright buckets attached to the rim of a wheel, moving in a reservoir of water; the buckets are filled at bottom as they pass through the water, and emptied at top, so that the water is raised to a height equal to the diameter of the wheel. The wheel may be turned by living power, or, if in running water, by fastening float-boards to the circumference. The Archimedian screw, the bucket-engine or chain-pump, and the rope-pump of Vera, are modifications of the same principle. 2. The next class of machines are those in which the water is raised by the pressure of the atmosphere, and comprises all those machines to which the name of *pump* is more particularly applied. (See PUMP.) These act entirely by removing the pressure of the atmosphere from the surface of the water, which may thus be raised to the height of about thirty-two feet. Whenever it becomes necessary to raise water to greater heights, the third class of machines, or those which act by compression on the water, either immediately or by the intervention of condensed air, are employed. All pumps of this description are called *forcing-pumps*. Although atmospheric pressure is not necessary in the construction of forcing-pumps, it is, in most cases, resorted to for raising the water, in the first place, into the body of the pump, where the forcing action takes place. In machines of this kind, the water may be raised to any height.

In the accompanying diagram are shown two forms of the sucking-pump. This species of pump acts by the pressure of the atmosphere, and consists of a cylinder furnished with a piston made to fit air-tight. When the piston is raised, a vacuum is formed in the tube beneath, and the water raised by the pressure of the air. On depressing the piston, the water passes through a valve or trap-door placed in the centre; and on the second elevation the water is forced to the top of the pump-barrel. To prevent the water returning to the well when the piston is depressed, a valve similar to that in the piston is placed at the bottom of the pump.



The force-pump is of more general application than the one already described. It consists of a cylinder and piston as in the former case, but the latter is constructed without a valve. In the right-hand figure of the following engraving, the piston sucks the water by its upward motion, but, on depressing it, the water passes by the side-pipe and enters the air vessel. The pipe placed in the centre serves to discharge the water, and the air by its elasticity ensures a continuous flow. In the left-hand figure, the piston is pierced for a valve, which would be too small to be indicated in the engraving, and, when the water is above the piston, it is discharged by the air-vessel placed at the top, as in the former case. In this arrangement of the pump, the water may be raised to any required height.



The fourth class of hydraulic machines for raising water consists of such engines as act either by the weight of a portion of the water which they have to raise, or of any other water that can be used for such purpose, or by its centrifugal force, momentum, or other natural powers; and this class, therefore, includes some very beautiful and truly philosophical contrivances, too numerous for us to describe: the Hungarian machine, the centrifugal pump, and the water-ram, are among the number. See WATER-RAM.

The third general division of the subject relates to the means by which motion and power may be obtained from liquids, and includes the general consideration of water-wheels and other contrivances for moving machinery. Motion is generally obtained from water either by exposing obstacles to the action of its current, as in water-wheels, or by arresting its progress in movable buckets, or receptacles which retain it during a part of its descent. Water-wheels have three denominations, depending on their particular construction, on the manner in which they are set or used, and on the manner in which the water is made to act upon them; but all water-wheels consist, in common, of a hollow cylinder or drum, revolving on a central axle or spindle, from which the power to be used is communicated, while their exterior surface is covered with vanes, float-boards, or cavities, upon which the water is to act. The undershot-wheel is the oldest construction of this kind: it is merely a wheel, furnished with a series of plane surfaces, or floats, projecting from its circumference, for the purpose of receiving the impulse of the water, which is delivered under the wheel. As it acts chiefly by the momentum of the water, the positive weight of which is scarcely called into action, it is proper to be used only where there is a great supply of water always in motion. It is the cheapest of all water-wheels, and is more applicable to rivers in their natural state than any other form of the wheel; it is also useful in tide-currents, where the water sets in opposite directions at different times, because it receives the impulse equally well on either side of its floats. In the over-shot wheel, the circumference is furnished with a series of cavities or buckets, into which the water is delivered from above, and is of course more powerful.

Fig. 8, *Plate* I., exhibits a very simple mode of employing a small stream of water. *a b c* represents a ver, supporting the bucket *e*. Any small stream of ater may be allowed to flow into this bucket; and,

when it acquires a given weight, the lever is depressed, carrying with it the pump-rod at *b*. When the bucket reaches the ground, a valve is opened in the bottom, which allows the fluid to escape; the pump-rod will then preponderate; and thus, by a continuous reciprocating motion of the great beam, the pump *d* is made to raise water.

Hydrocephalus. See Dropsy.

Hydrogen; a simple body, producing water by its combination with oxygen, in allusion to which the name *hydrogen* has been applied. The most simple state in which we can procure it is in that of a gas, i. e. in union with caloric, and possibly with electricity and light. To effect this, water is employed, and one of the following arrangements is usually adopted: water, in the state of vapour, is passed over clean iron heated to redness, by adjusting a retort, half filled with this fluid, to one extremity of an iron tube containing clean iron wire, and laid across a heated furnace, the other extremity having a bent tube connected with it, and dipping under the shelf of a pneumatic cistern; the water in the retort is made to boil briskly, and the steam to come in contact with the heated iron; upon which hydrogen gas is copiously disengaged, and collected in the pneumatic apparatus. Or slips of sheet zinc, iron filings, or turnings, or small iron nails, are introduced into a small gas-bottle with a bent tube, or into a common retort, upon which sulphuric acid, diluted with five or six times its weight of water, is poured; effervescence ensues, and the escaping gas may be collected in the usual manner. One Troy ounce of zinc gives about 356 oz. measures = about 676 cubic inches; and 1 oz. of iron, 412 oz. measures = 782 cubic inches, of hydrogen gas. The hydrogen obtained in these processes is not absolutely pure. The gas evolved during the solution of iron is contaminated by a compound formed from hydrogen and the carbon contained in the iron. This compound is removed by transmitting the gas through alcohol. The gas obtained by means of zinc is more free from impurities; though the small proportion of sulphur and carbon still remaining in the zinc of commerce gives rise to the same compound as in the former case, and also to a little sulphuretted hydrogen.

The impurities in this instance are removed by passing the gas through a solution of caustic potash. Thus purified, hydrogen gas has neither taste nor odour; it is colourless, and the lightest of all ponderable matter known, its specific gravity being 0.073, that of atmospheric air being 1.000, or about thirteen times lighter than common air. This remarkable levity allows it to ascend with the greatest readiness through all liquids and gases, and is the cause of its being employed to fill balloons, which, notwithstanding the weight of the materials of which they are constructed, are sufficiently light, compared with the atmosphere, to rise to very great elevations, or until they meet with a medium whose density is such as to render them stationary.

Hydrogen gas is a powerful refractor of light, and has hitherto resisted all attempts to compress it into a liquid. It is sparingly absorbed by water, 100 cubic inches of that liquid taking up about $1\frac{1}{2}$ of the gas. It is incapable of supporting respiration; nor is it a supporter of combustion; for, when a lighted taper is passed up into an inverted glass full of hydrogen gas, it is immediately extinguished. But its most characteristic property is that of its inflammability, though, like other combustibles, it requires the aid of a supporter for enabling its combustion to take place. This is exemplified by bringing a lighted candle or taper to the mouth of a narrow jar, or wide-mouthed bottle, filled with the gas; it is immediately kindled, but only burns where it is in contact with the air, the combustion going on quietly in successive strata from the orifice to the bottom of the vessel. Mingled with oxygen gas, no action takes place so long as the compound remains cold; but, on the approach of a flame, the whole is kindled at the same instant; a flash of light passes through the mixture, followed by a violent explosion. The report is the loudest when the proportions observed in the mixture are two volumes of hydrogen and one of oxygen.

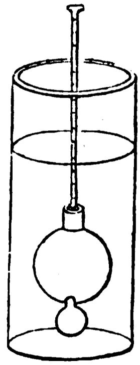
The same phenomena take place, though less strikingly, when atmospheric air is substituted for oxygen gas: in the latter case, however, the proportions are two measures of hydrogen to five or six of air. And not only is hydrogen gas inflamed when in contact with air or oxygen gas by the contact of a burning taper, but by a solid body heated to redness, and by the electric spark. If a jet of hydrogen is delivered upon recently-prepared spongy platinum (see Platinum), this metal very quickly becomes red-hot, and then sets fire to the gas. The electric spark ceases to cause detonation when the explosive mixture, formed of two measures of hydrogen to one of oxygen, is diluted with twelve times its volume of air, fourteen of oxygen, or nine of hydrogen, or when it is expanded to sixteen times its bulk by diminished pressure. Sudden and violent compression, likewise, causes an explosion of the gaseous mixture, apparently from the heat emitted during the operation; for an equal degree of condensation, slowly produced, has not the same effect. When the action of heat, the electric spark, and spongy platinum, no longer cause an explosion, a silent and gradual combination between the gases may still be occasioned by them. Oxygen and hydrogen gases unite slowly with one another when exposed to a temperature above the boiling point of mercury, and below that at which glass begins to appear luminous in the dark. An explosive mixture, diluted with air to too great a degree to explode by electricity, is made to unite silently by a succession of electric sparks. Spongy platinum causes them to unite slowly, though mixed with 100 times their bulk of oxygen gas. A very high temperature is excited by the combustion of hydrogen gas, especially when it is burned in oxygen gas, as in the compound blow-pipe of Doctor Hare. Water is the sole product of the combustion of hydrogen—a fact first demonstrated by Cavendish, who burned oxygen and hydrogen gases in a dry glass vessel, and obtained a quantity of pure water exactly equal to that of the gases which had disappeared during the experiment. The synthetic proof of the composition of water is obtained also by detonating two measures of hydrogen, mixed with one of oxygen, in a tube, over the mercurial cistern; the whole is condensed into water. Lavoisier first exhibited the composition of water analytically, by passing a known quantity of watery vapour over metallic iron heated to redness in a glass tube. Hydrogen gas was disengaged; and the weight of the hydrogen, added to the increase which the iron had experienced from combining with oxygen, exactly corresponded to the quantity of water which had been decomposed.

The processes for procuring a supply of hydrogen, described at the commencement of the present article, will now be intelligible. The first is founded on the fact that iron, at a red heat, decomposes water, the oxygen of which unites with the metal, while the hydrogen gas is set free. That the hydrogen which is evolved, when zinc or iron is put into dilute sulphuric acid, is derived from water, is obvious from the consideration that of the three substances iron or zinc, sulphuric acid, and water, the last is the only one which contains hydrogen. The product of the operation, besides hydrogen, is the sulphate of the protoxide of iron, if iron is used, or of the oxide of zinc, when zinc is employed. Hydrogen, therefore, is one of the most abundant substances in nature. Besides, with carbon and oxygen, it enters into the composition of all vegetable substances; and, with oxygen, carbon, and nitrogen, it forms a part of all animal substances. Large quantities of it, often united with more or less of carbon, are continually evolved into the atmosphere from the decomposition of vegetable and animal matters.

HYDROGRAPHY; that part of geography which treats of waters.—*Hydrographic maps;* such as make the rivers and other collections of water their chief subject.

HYDROMETER, a measurer of density (for fluids), is an instrument which, being immersed in fluids, as in water, brine, beer, brandy, determines the proportion of their densities or their specific gravities, and thence their qualities. The use of the hydrometer depends on the following propositions:—1. The hydrometer will sink in different fluids in an inverse proportion to the density of the fluids; 2. the weight required to sink a hydrometer equally far in different fluids will be directly as the densities of the fluids. Each of these two propositions gives rise to a particular kind of hydrometer: the first with the graduated scale; the second with weights. The latter deserves the preference.

There are various instruments used as hydrometers; one is a glass or copper ball, with a stem, on which is marked a scale of equal parts or degrees. The point to which the stem sinks in any liquid being ascertained and marked on the scale, we can tell how many degrees any other liquid is heavier or lighter, by observing the point to which the stem sinks in it. This instrument is shown in the accompanying figure.



Another kind is formed by preparing a number of hollow glass beads of different weights, and finding which bead will remain stationary in any liquid, wherever it is placed. An instrument of great delicacy, which will even detect any impurity in water too slight to be detected by any ordinary test, or by the taste, consists of a ball of glass three inches in diameter, with another joining it, and opening into it, one inch in diameter. A wire, about ten inches long and one-fortieth of an inch in diameter, divided into inches and tenths, is screwed into the larger ball. A tenth of a grain, placed on the top of the wire, will sink it a tenth of an inch. Now it will stand in one kind of water a tenth of an inch lower than in another, which shows that a bulk of one kind of water equal to the bulk of the instrument (which weighs 4000 grs.) weighs one-tenth of a grain less than an equal bulk of the other kind of water; so that a difference in specific gravity of one part in 40,000 is detected.

The *aræometer* is more simple and accurate. A glass phial, about two inches in diameter, and seven or eight long, is corked tight; into the cork is fixed a straight wire one-twentieth of an inch in diameter and thirty inches long. The phial is loaded with shot so as to sink in the heaviest liquid, leaving the wire just below the surface. The liquor is then placed in a glass cylinder three or four feet long, with a scale of equal parts on the side, by which the point to which the top of the wire sinks is marked. This instrument is so delicate that the sun's rays falling upon it will cause the wire to sink several inches; and it will rise again when carried into the shade.

HYDROPHOBIA; a specific disease, arising from the bite of a rabid animal. The animals most liable to be afflicted with madness are dogs; but cats, wolves, foxes, &c., are also subject to it. The accompanying description of the way in which rabies affects dogs is highly important when danger from the disease is apprehended. The symptoms of rabies in the dog are the following, and are given nearly in the order in which they usually appear:—An earnest licking, or scratching, or rubbing of some particular part; sullenness, and a disposition to hide from observation; considerable costiveness and occasional vomiting; an eager search for indigestible substances—as bits of thread, hair, straw, and dung. The dog becomes irritable; quarrels with his companions; eagerly hunts and worries the cat; mumbles the hand or foot of his master, or perhaps suddenly bites it, and then crouches and asks pardon. As the disease proceeds, the eyes become red: they have a peculiar bright and fierce expression. Some degree of strabismus, or squinting, very early appears—not the protrusion of the *membrana nictitans* over the eye, which, in distemper, often gives the appearance of squinting, but an actual distortion of the eyes; the lid of one eye is evidently more contracted than that of the other; twitchings occur round that eye; they gradually spread over that cheek, and finally over the whole face. In the latter stage of the disease, that eye frequently assumes a dull green colour, and at length becomes a mass of ulceration.

After the second day the dog usually begins to lose a perfect control over the voluntary muscles. He catches at his food with an eager snap, as if uncertain whether he could seize it; and he often fails in the attempt. He either bolts his meat almost unchewed, or, in the attempt to chew it, suffers it to drop from his mouth. This want of power over the muscles of the jaw, tongue, and throat increases, until the lower jaw becomes dependent, the tongue protrudes from the mouth, and is of a dark and almost black colour. The animal is able, however, by a sudden convulsive effort, to close his jaws, and to inflict a severe bite. The dog is in incessant action; he scrapes his bed together, disposes it under him in various forms, shifts his posture every instant, starts up, and eagerly gazes at some real or imaginary object; a peculiar kind of delirium comes on; he traces the fancied path of some imaginary object floating around him; he fixes his gaze intently on some spot in the wall or partition, and suddenly plunges and snaps at it; his eyes then close, and his head droops, but the next moment he

starts again to renewed activity: he is in an instant recalled from this delirium by the voice of his master, and listens attentively to his commands; but, as soon as his master ceases to address him, he relapses into his former mental wandering. His thirst is excessive (there is no hydrophobia, or fear of water, in the dog), and, the power over the muscles concerned in deglutition being impaired, he plunges his face into the water up to the very eyes, and assiduously, but ineffectually, attempts to lap. (In Johnson's *Shooter's Companion* the author observes, "In those instances of hydrophobia which have fallen under my notice, the animal has always been capable of lapping; however, in the disease called *dumb madness*, I have noticed symptoms similar to the above.") His desire to do mischief depends much on his previous disposition and habits. He springs to the end of his chain; he darts with ferocity at some object which he conceives to be within his reach; he diligently tears to pieces every thing about him; the carpet or rug is shaken with savage violence; the door or partition is gnawed asunder; and so eager is he in this work of demolition, and so regardless of bodily pain, that he not unfrequently breaks one or all of his teeth. If he effects his escape, he wanders about, sometimes merely attacking those dogs which fall in his way; and at other times he diligently and perseveringly hunts out his prey: he overcomes every obstacle to effect his purpose; and, unless he has been stopped in his march by death, he returns in about four and twenty hours, completely exhausted, to the habitation of his master. He frequently utters a short and peculiar howl, which, if once heard, can rarely be forgotten; or, if he barks, it is with a short, hoarse, inward sound, altogether dissimilar from his usual tone.

In the latter stages of the disease, a viscid saliva flows from his mouth, with which the surface of the water that may be placed before him is covered in a few minutes; and his breathing is attended with a harsh grating sound, as if impeded by the accumulation of phlegm in the respiratory passages. The loss of power over the voluntary muscles extends, after the third day, throughout his whole frame, and is particularly evident in the loins; he staggers in his gait; there is an uncertainty in all his motions; and he frequently falls, not only when he attempts to walk, but when he stands, balancing himself as well as he can. On the fourth or fifth day of the disease, he dies, sometimes in convulsions, but more frequently without a struggle. After death, there will invariably be found more or less inflammation of the mucous coat of the stomach; sometimes confined to the rugæ, at other times in patches, generally with spots of extravasated blood, and occasionally intense, and occupying the whole of that viscus. The stomach will likewise contain some portion of indigestible matter (hair, straw, dung), and, occasionally, it will be completely filled and distended by an incongruous mass. The lungs will usually present appearances of inflammation, more intense in one, and generally the left lung, than in the other. Some particular points and patches will be of a deep colour, while the neighbouring portions are unaffected. The sublingual and parotid glands will be invariably enlarged, and there will also be a certain portion of inflammation, sometimes intense, and at other times assuming only a faint blush, on the edge of the epiglottis, or on the rima glottidis, or in the angle of the larynx at the back of it. The hydrophobia seems to be spontaneous, and capable of being communicated only by certain animals—the dog, the wolf, the fox, and the cat.

All animals which have become rabid by a bite do not appear to be able to transmit it to others; as the hog, cow, sheep. In regard to man, it is not certain whether the disease is communicable from the human subject. The hydrophobia is not commonly manifested in the time of greatest cold or greatest heat, but usually in March and April in wolves, and in May and September in dogs. It is rare in very warm or very cold climates. No particular cause of the rabies is known; it is a mistake to attribute it to a total privation of food, as a great number of experiments prove that this is not the effect of such a treatment. All observations seem to prove the existence of a rabid virus, which is more violent when it proceeds from wolves than from dogs; as, out of a given number of persons bitten by a rabid wolf, a greater number will die than out of the same number bitten by a dog. The communication of the virulent hydrophobia by inoculation cannot be denied, and is the best proof of the existence of the virus. The virus appears to be contained solely in the saliva, and does not produce any effect on the healthy skin. But if the skin be deprived of the epidermis, or if the virus be applied to a wound, the inoculation will take effect. The developemént of the rabid symptoms is rarely immediate; it seldom takes place before the fortieth or after the sixtieth day. It begins with a slight pain in the scar of the bite, sometimes attended with a chill; if the bite was on the lower limbs, the pain extends and reaches the base of the breast, or, if on the upper extremities, the throat. The patient becomes silent; frightful dreams disturb his sleep; the eyes become brilliant; pains in the neck and throat ensue. These symptoms precede the rabid symptoms two or three days. They are followed by a general shuddering at the approach of any liquid or smooth body, attended with a sensation of oppression, deep sighs, and convulsive starts, in which the muscular strength is much increased. After the rabid fit the patient is able to drink. The disposition to bite does not appear to belong to any animals except those whose teeth are weapons of offence: thus rabid sheep do not bite, though they butt furiously. A foamy, viscid slaver is discharged from the mouth; the deglutition of solid matters is difficult; the respiration hard; the skin warm, burning, and afterwards covered with sweat; the pulse strong. The fits are often followed by a syncope; they return at first every few hours, then at shorter intervals, and death takes place generally on the second or third day.

A great number of applications have been recommended, but without success. The treatment of the disease is of two sorts: the one consists in preventing its developement; the other in checking its progress. The former consists in cauterizing the wound with iron heated to a white heat, the pain of the cautery being less as the temperature is greater. The cautery is preferable to the use of lotions, liniments, &c., but it should be employed within twelve hours after the bite. It has been said that, in patients who were about to become rabid, several little pustules filled with a serous matter appeared under the tongue, the opening of which would prevent the disease; but this is not well established. A mode of treatment which has in many cases been attended

HYDROSTATICS & HYDRAULICS.

Fig. 5.

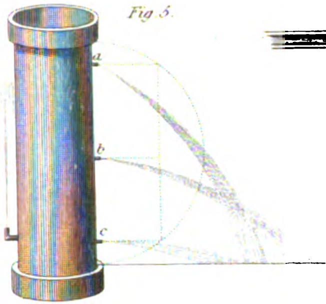


Fig. 6.

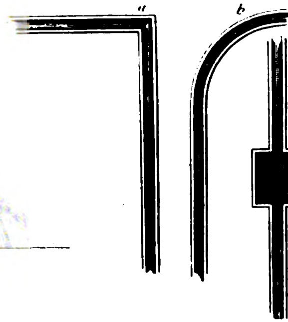


Fig. 1.

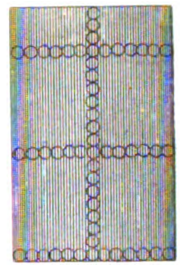


Fig. 9.

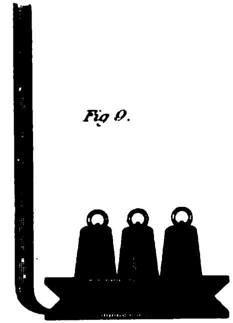


Fig. 4.

Fig. 3.

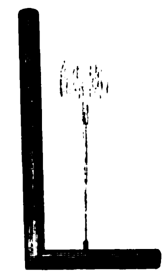


Fig. 8.

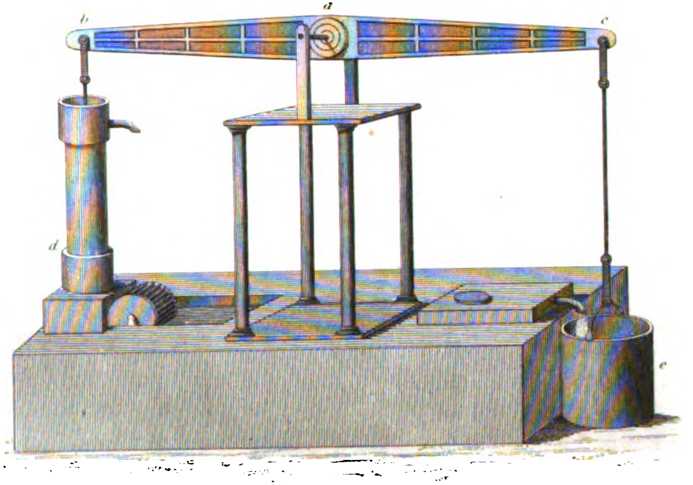


Fig. 2.

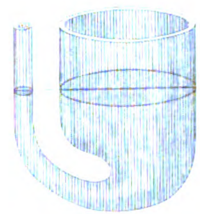
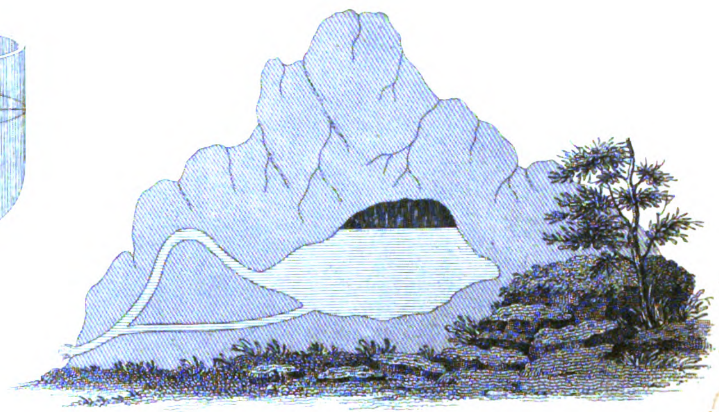


Fig. 7.



London, Published by William Orr, Paternoster Row, June 29, 1833.

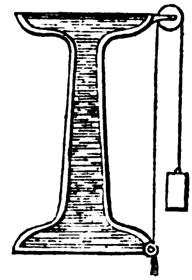
with success must now be adverted to. It consists in the application of a cupping-glass to the lacerated part, which, by forming a vacuum over the wound, prevents the virus being imbibed, and taken into the system. It will be obvious that the application of the cupping instrument must speedily follow the infliction of the wound, and, when the poison is brought to the surface, the knife or cautery may be resorted to. Various remedies have been prescribed for the cure of a declared hydrophobia. Bleeding, even to syncope, appears to have produced the greatest effect, but without complete success. Preparations of opium administered internally or by injection, mercurial frictions, belladonna, emetics, sudorifics, purgatives, &c., have been tried ineffectually. Yet the physician should not despair, as a remedy which has failed in one case may succeed in another. Above all, the patient should be treated gently, and his sufferings alleviated by consulting his comfort as much as possible; and the attendants should not forget that there is no instance of the rabies having been communicated from one man to another.

Hydrostatics is the science which treats of the weight, pressure, and equilibrium of liquid fluids. The particles in liquids are freely movable among each other, so as to yield to the least disturbing force; but, though it was formerly believed that liquid fluids were incompressible, recent experiments have shown that they may be indefinitely condensed by pressure. The fundamental truth, on which the whole science of hydrostatics rests, is equality of pressure. All the particles of fluids are so connected together that they press equally in every direction, and are continually pressed upon; each particle presses equally on all the particles that surround it, and is equally pressed upon by them; it equally presses upon the solid bodies which it touches, and is equally pressed by those bodies. From this, and from their gravity, it follows that when a fluid is at rest, and left to itself, all its parts rise or fall so as to settle at the same level, no part standing above or sinking below the rest.

The freedom of motion which is peculiar to all fluid bodies is supposed to arise from their particles being of a spherical form. *Fig.* 1, *Plate* I., Hydrostatics and Hydraulics, represents a series of these particles; and a slight reference to their arrangement must show that they can only arrange themselves in a position parallel to the plane of the horizon. The perpendicular line of globules would evidently slide by each other and assume parallel horizontal strata, occupying the lower part of the vessel; and between the interstices of the circles smaller spherules might be placed, as is the case when we add certain crystalline bodies to water without increasing its bulk.

In *fig.* 2 we have an illustration of this fact, the water rising to the same height in the small tube as in the larger vessel.

The general rule for estimating the pressure of any fluid is to multiply the height of the fluid by the extent of the surface on which it stands. If any portion of the fluid be supported by a tube above the remainder, the pressure on the bottom of the vessel will be the same as if the water were throughout at the same height as that in the tube, so that the height of the tube is properly multiplied by the extent of the bottom of the vessel to determine the whole pressure. This principle of equal pressure has been called the *hydrostatic paradox*, though there is nothing in reality more paradoxical in it than that one pound at the long end of a lever should balance ten pounds at the short end: it is, indeed, but another means, like the contrivances called *mechanical powers*, of balancing different intensities of force by applying them to parts of an apparatus which move with different velocities.



The glass apparatus for exhibiting the hydrostatic paradox is shown in the accompanying wood-cut. This law of pressure is rendered very striking in the experiment of bursting a strong cask by the action of a few ounces of water. Suppose a cask already filled with water, and let a long tube be screwed tightly into its top, which tube will contain only a few ounces of water; by filling this tube the cask will be burst. The explanation of the experiment is this: if the tube have an area of a fortieth of an inch, and contain half a pound of water, this will produce a pressure of half a pound upon every fortieth of an inch over all the interior of the cask. The same effect is produced in what is called the *hydrostatic bellows*. The tube is made to communicate with an apparatus constructed like a common bellows, but without a valve. If the tube hold an ounce of water, and have an erea equal only to one-thousandth of that of the top board of the bellows, an ounce of water in the tube will balance weights of a thousand ounces resting on the bellows. The bellows as usually constructed for this experiment are shown at *fig.* 9, *Plate* I., Hydrostatics and Hydraulics.

Hydrostatic Press. The press originally invented by Mr. Bramah is one of the most valuable hydrostatic machines yet constructed. *Plate* II., Hydrostatics and Hydraulics, contains a very accurate view of its various parts, drawn to such a scale as to admit of any competent workman making a similar press.

Fig. 10 is an elevation of the press, consisting of wrought-iron rods, connecting cast plates, which form the base and upper part of the frame. In this rises the ram-head, *a*, which operates on the materials to be pressed at *b*. At the side of the press is placed a force-pump with its handle and piston, *d e*. The water raised by the pump is injected by the pipe *c*. A plan of the machine, taken from the base of the press, is given at *fig.* 11.

The principle of the press may be best explained by reference to *fig.* 12. If we suppose the area of the piston *a* to contain 100 inches, and the injecting pipe *c* to be equal to one inch, a column of water entering with a force of 20lbs. would operate with a force of 2000lbs. on the piston. To make this more clear, we should bear in mind that, as fluids press equally in every direction, each inch of the piston must be acted upon with a force equal to that in the injecting pipe. It must not, however, be forgotten that the ascending velocity of the piston will only be one-hundredth of that of the water in the force-pump; and, as such, that it will take 100 times longer to press the goods than would be the case if that enormous power could at once be applied to the great piston. The force-pump, by which the water is introduced, is shown at *fig.* 13. At each elevation

of the piston, *d*, the water rises by the suction-pipe *c*, and when it is depressed the water passes on towards the screw *g*. If that be forced down by the lever above, the water passes along by a side-pipe, and enters the great cylinder.

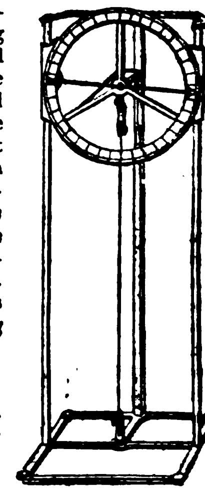
The safety-valve with its weight is shown in *figs.* 10 and 11. In *fig.* 13 an end view of the safety-valve is given, and at *fig.* 14 the entire series of valves are delineated on a larger scale. The screw which holds down the first valve is shown at *fig.* 15. To insure the accurate fitting of the piston, a very beautiful contrivance is usually resorted to: it consists in the employment of a flexible band of leather, a portion of which is given at *fig.* 16; so that, when the pressure of the water is increased, it raises the leather, and increases the resistance, thus preventing the escape of the fluid.

If we suppose the goods to have received the requisite amount of compression, the piston is depressed by slightly withdrawing the screw *g*, when the water descends the pipe, and enters the cistern, whence it may be raised by the pump, as in the previous operation.

HYGROMETER, HYGROSCOPE. It is of the greatest importance in meteorology to ascertain at any time the quantity of water contained in the air. The instruments used for this purpose are called *hygrometers* (measurers of moisture). Daily experience shows that some bodies possess a great capability of absorbing the humidity suspended in the atmosphere, and, according to their respective construction, becoming longer or shorter in the direction of the fibres of their length or breadth. Thus, for example, cordage and catgut are shortened and untwisted by moisture.

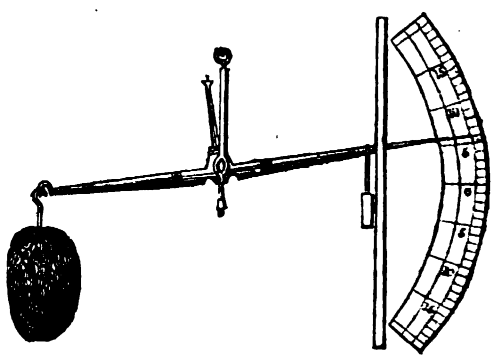
There is a mode of constructing this instrument which is cheap as well as delicate in its operation. It consists of a small bag made of the internal membrane of the *arundo phragmites*. This bag or bladder is tied to the end of a capillary tube, and filled with mercury. Any change in the moisture of the atmosphere will change the dimensions of the bag, and, as such, cause the mercury to rise or fall in the tube. The zero of the scale in this instrument marks absolute humidity, and the other extremity absolute dryness. The lower end of the glass tube, instead of being merely inserted in the top of the bag, may pass through it, the mercury in the bag communicating with that in the tube by one or more openings made through the sides of the tube. By this means, the bag may be supported by the glass and prevented from being injured by any slight accident, and the instrument is also less affected by any change of temperature.

The principle thus developed is the foundation of the hygrometer of Lambert, which, however, on account of the irregularity of the motion produced in the catgut by the humidity, does not altogether answer its purpose, but properly deserves the name of a *hygroscope* (indicator of moisture). Saussure and De Luc, therefore, sought for other substances, which are regularly lengthened or shortened by the absorption or loss of humidity. Saussure believed this property might be found in a human hair, freed from all unctuosity by boiling in ley; De Luc, in a very thin piece of whalebone, cut in a direction transverse to the fibre. Saussure stretched the hair, properly prepared, and fastened at one end, over a delicate and easily movable wheel, by a small weight, while De Luc made use of a small wire of gold to stretch the whalebone. Whenever the hair in Saussure's hygrometer is lengthened or shortened by the action of the moisture or dryness, the wheel, and an index attached to it, must be turned, and thus mark the increase or diminution of the water suspended in the atmosphere.



This species of hygrometric apparatus is shown in the accompanying figure. The following means were employed to find the points of extreme moisture and dryness. Saussure fixed the point of extreme moisture in his hygrometer by placing it in a glass receiver, enclosed in water and moistened with water within; De Luc, on the other hand, accomplished the same object by simply immersing his hygrometer in water. The point of extreme dryness Saussure determined by placing his hygrometer under a receiver, which stood on a tin plate, heated to a red heat, and covered with red-hot potash; De Luc by suspending the hygrometer in a close vessel, partly filled with hot quick-lime.

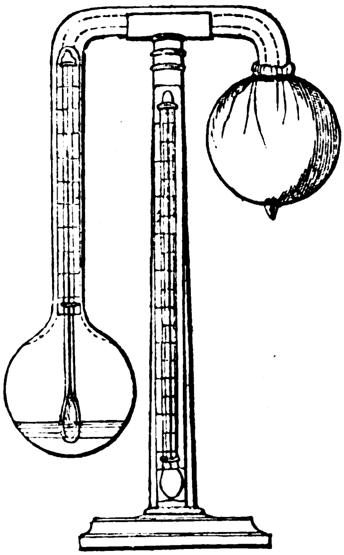
There is a very simple form of the hygrometer which may now be adverted to. The instrument consists of a balance beam, furnished with a piece of sponge at one extremity, and a slender rod or index at the other. The sponge should be prepared by steeping in pearl-ash and water, which renders it more hygrometric. The balance is usually constructed so that the points of suspension are considerably higher than the centre of gravity of the entire beam, so that, when the sponge imbibes moisture from the air, the opposite end gradually ascends; and when, on the contrary, the water is again absorbed, the index passes towards the opposite end of the graduated circle shown in the figure.



The weight at the index end of the balance is in the present case employed only as a couuterpoise to the sponge.

The hygrometer invented by Mr. Daniell is more accurate than those we have already described. It is, however, more costly, and requires a longer period of time for registering each observation. An en-

graving of the apparatus is given beneath. It consists of two thin glass balls of 1½ inch in diameter, connected together by a tube, having a bore of about one-eighth of an inch. The tube is bent at right angles over the two balls, and one arm contains a small thermometer, whose bulb, which must be of a lengthened form, descends into the ball. This ball, being about two-thirds filled with ether, is heated over a lamp till the fluid boils, and the vapour issues from the capillary tube, which terminates the highest ball. The vapour having expelled the air from both balls, the capillary tube is closed hermetically by the flame of a lamp. The upper ball is now to be covered with a piece of muslin. The stand is of brass, and the transverse socket at top is made to hold the glass tube, in the manner of a spring, allowing it to turn and be taken out with little difficulty. A small thermometer is inserted into the pillar of the stand.



The manner of using the instrument may be thus described:—After having driven all the ether into the lower ball, by the heat of the hand, it is to be placed in an open window, or out of doors, with the ball so situated as that the surface of the liquid may be upon a level with the eye. A few drops of ether are then to be poured upon the covered ball. Evaporation immediately takes place, which, producing cold upon the ball, causes a rapid and continuous condensation of the ethereal vapour in the interior of the instrument. The consequent evaporation from the included ether produces cold in the lower ball, the degree of which is measured by the thermometer within. This action is almost instantaneous. The thermometer begins to fall in two seconds after the ether has been dropped. A depression of thirty degrees is easily produced, and sometimes the ether boils, and the thermometer falls below 0° of Fahrenheit's scale. The artificial cold thus produced causes a condensation of the atmospheric vapour upon the lowest ball, which first makes its appearance in a thin ring of dew coincident with the surface of the ether. The degree at which this takes place is to be carefully noted. A little practice may be necessary to seize the exact moment of the first deposition, but certainty is very soon acquired. It is advisable to have some dark object behind the instrument, such as a house or a tree, as the cloud is not so soon perceived against an open horizon. The depression of temperature is first produced at the surface of the liquid where evaporation takes place; and the currents which immediately ensue, to restore the equilibrium, are very perceptible. The bulb of the thermometer is not quite immersed in the ether inclosed in the bulb. The greatest difference that Mr. Daniell observed, in the course of four months' daily experiments, between the external thermometer and the internal one, at the moment of precipitation, in the natural state of the atmosphere, was twenty degrees. In very damp weather the ether should be slowly dropped upon the ball, otherwise the descent of the thermometer is so rapid as to render it impossible to be certain of the degree. In dry weather, on the contrary, the ball requires to be well wetted more than once, to produce the requisite degree of cold. It is almost superfluous to observe that care should be taken not to permit the breath to affect the glass. With these precautions the observation is simple, easy, and certain.

When the instrument is required to act merely as a weather-glass, to predict the greater or less probability of rain, &c., which is the commonest use to which it can be applied, the difference between the constituent temperature of the vapour and that of the air is all that is necessary to be known. The probability of rain, or other precipitation of moisture from the atmosphere, is in an inverse proportion to this difference. As a weather-glass, this hygrometer is more to be depended upon than any instrument that has yet been proposed.

By combining the rise and fall of the barometer with the effects of this instrument, we learn to modify their results, and by so doing can hardly be deceived in the weather for many hours in advance. The indications are to be corrected according to circumstances in the following manner:—In summer time, when the diurnal variations of temperature are great, regard is to be had to the time of day at which the experiment is made. In the morning, supposing the difference between the temperature of the air and the constituent temperature of the vapour to be small, it is to be recollected that the accession of heat during the day is great, and that the difference will therefore probably increase. If the point of condensation should at the same time be lowered, it is an indication of very fine weather. If, on the contrary, the heat of both should increase with the day in nearly equal progression, rain will almost infallibly follow, as the heat of the air falls with the setting sun. In showery weather the indications of this instrument vary rapidly three or four degrees, and a person making observations at short intervals of time may easily predict the approach of a storm.

Fogs also, and mists, must be taken into consideration. They produce the same effect upon the instrument as the greater precipitation of rain. A change from fine weather to rain is more quickly perceptible in low situations than one from wet to fine; for the effect of a shower lasts rather longer than the state of the atmosphere in higher regions would warrant, on account of the damp exhalations from the moistened ground.

In cases of mist, fog, and cloud, the instrument will sometimes exhibit a different kind of action. If it be brought from an atmosphere of a higher temperature into one of a lower degree, in which condensed aqueous particles are floating, the mist will begin to form upon the ball at a temperature several degrees higher than that of the air. The difference, Mr. Daniell believes, is proportionate to the density of the cloud or mist; but, this philosopher says, "I speak with diffidence upon this point, as I have not had sufficient opportunities of verifying it by experi-

ment. I have sometimes thought that I have perceived a difference in this respect in different modifications of the cloud, but this must be referred to future more extended observations. This action upon floating water does not at all interfere with it as measuring the force and quantity of vapour; for in all such cases the full saturation of the atmospheric temperature must take place, and consequently the temperature of the vapour must be coincident with that of the air."

The hygrometer we have now described excels all others in the sensibility and accuracy with which it marks the comparative degrees of moisture and dryness in the atmosphere, and, by exhibiting them in degrees of the thermometer, refers them to a known standard of comparison, and thus speaks in a language which every body understands.

Hypochondriasis; one of the most troublesome of diseases. Its seat is in the abdomen, particularly under the short ribs; but, when it has increased to a certain degree, it manifests itself in the most various ways in the whole body, as there are few diseases of which the hypochondriac does not at some time or other complain. He feels a pressure on the right side, and thinks it is owing to a complaint of the liver; he has pains in the breast, and immediately apprehends inflammation of the lungs; his head feels heavy, and nothing is more certain than an approaching apoplexy; he sees specks before his eyes, and a cataract is unavoidable; and, if the heart beats stronger than usual, a polypus in that organ is probable. All these effects of the disease are explicable, from its nature, seat, and causes.

Hypochondria is a disturbance of the functions of the nervous system of the abdomen. Hence the sensibility of the nervous system is morbidly heightened, but its power of action lessened. At the same time, the separation between the nervous system of the abdomen and that of the brain is rendered less complete, so that certain feelings reach the brain, and thus affect the thoughts much more than in a state of health. The disturbance in the function of the abdominal nervous system produces next a weakness and disturbance in the digestion, which generally produce the first and most numerous attacks of hypochondria, from which all the others originate, in proportion as the morbid sympathy extends over the whole body. Hence, first, is produced spasmodic contractions under the short ribs, sometimes on one side, sometimes on the other, sometimes in the pit of the stomach; torpidity of the bowels, flatulency, inflation of the abdomen, want of appetite, increased pressure, and, generally, disagreeable feelings after eating.

In the progress of the disease, a slow and somewhat difficult inspiration comes on, indescribable anxiety, and pain and giddiness in the head. Also, when the stomach is empty, this organ sometimes suffers pain and sickness, and vomiting takes place. For moments, particularly after digestion is finished, the hypochondriac feels easy, well, and serene; but, all at once, the old complaints seize again upon their victim. The disturbance of the nervous system also has, as may well be conceived, a great influence upon the mind and humour of the patient. Sometimes he is melancholy, sometimes gay to an excess. Uninterruptedly occupied with the state of his body, he takes notice of every feeling, and wishes to have every trifling pain explained, considering every one as a symptom of a serious disease. For every thing he wants medicine. In the hours of anxiety, hypochondriacs are constantly in dread of death. Sometimes anxiety attacks them so suddenly that they must jump up, and cannot find quiet any where. Sometimes memory leaves them, so that they cannot think of their name. In the midst of the most serious conversation, nay, even of prayers, the most ludicrous ideas or images strike them. Others, all at once, feel a desire to perform the strangest actions, from which they can restrain themselves only with great difficulty.

This deplorable disease may be occasioned by any circumstances which disturb the functions of the abdominal nervous system, heighten its sensitiveness, debilitate digestion, and lessen the separation of the reproductive nervous system from the sensitive. Among the chief causes are great exertions of the mind in studying, a sedentary or dissipated life, excess in exciting liquors, and even coffee; also want of exercise of the physical and mental powers, producing *ennui*. Hypochondria is physically considered not a dangerous disease. It is true, the genuine hypochondriac believes, at least for six days of every week, that his hour is come. He passes a wretched existence, and is a real torment to his family and physician. Hypochondria can be cured but slowly. A hypochondriac must abstain from much medicine, but the difficulty is to persuade him to do so. He ought to master his feelings, but the body has become the governing power; he ought to take much exercise, but his indolence finds continual excuses for omitting it; he ought to observe a strict diet for years, but he is impatient to be cured immediately, and his most solemn promises are forgotten in a week. Thus it happens that a hypochondriac is seldom entirely cured, but, after having suffered for years, he dies of some additional disease: or, in very advanced age, when the irritability of the nerves is lessened, the disease disappears.

Hypogastric (from ὑπο, under, and γαστηρ, the abdomen); seated in the lower part of the belly.

Hysterics are with women nearly the same as hypochondria with men, the difference which really exists arising from the peculiar character and constitution of women. It arises from a morbid excitement of the nervous system, and manifests itself by great uneasiness, unusual susceptibility, occasioning great trouble, often from imaginary causes, and affecting the sufferer even to tears. To these is added the sensation of a ball mounting from the abdomen, and particularly from the pit of the stomach, where the most important nerves concentre, and occasioning a feeling of strangulation. From the greater susceptibility in the system of women, these affections are more universal, and appear quicker in other parts of the body, particularly in the muscles, than in men. Hence spasms of various kinds, contractions of the neck, pains in the head, fainting fits, palpitation of the heart, appear very frequently, and are sometimes so severe that persons afflicted with them seem to be dying. These complaints were once ascribed to vapours arising from the stomach, and were called by that name. Women of a delicate habit, and whose nervous system is extremely sensible, are the most subject to hysterical affections; and the habit which predisposes to these attacks is acquired by inactivity and a sedentary life, grief, anxiety, and various physical disorders. They are readily excited,

in those who are subject to them, by strong emotions, especially if sudden. Hysterical complaints are best prevented by a judicious care of the moral and physical education of girls. Men of uncommon nervous sensibility are sometimes subject to disorders not essentially different.

ICE; every frozen liquid: in a more limited sense, frozen water. As soon as the temperature is raised, the solid state again gives way to the liquid. We see, then, that ice is nothing but water deprived of its caloric. The freezing of water is a phenomenon so remarkable that the greatest naturalists have thought it worthy of a careful investigation. Expose a glass, filled with water, to a degree of cold producing ice; an extremely thin film of ice is observed first on the surface of the water in contact with the cold air. Slender threads of ice are soon seen to shoot out from the sides of the vessel, generally forming with it obtuse or acute, seldom right angles; from these rays, new ones continually shoot out, till the whole surface is covered with a single coating; while this process is going on, a great number of air-bubbles arise, as in boiling, which pass out of the water when the congelation is slow; but, when it is sudden, they are frozen in, and by their expansion cause rents in the ice.

Although cold generally produces contraction, ice occupies a larger space than water; it is hence specifically lighter, and floats upon it. Those persons are in an error who suppose that *ground-ice*, as it is called, rises from the bottom of the water after freezing. A species, however, called *anchor-ice*, appears to be formed at the bottom, or, at least, under the surface, of rapid rivers, perhaps owing to the comparatively slow motion of the water at the bottom of a stream. It is well known that stagnant water freezes sooner than flowing water: perfect rest, however, seems to be unfavourable to freezing; for we know by experience that water perfectly still is not frozen when its temperature is reduced much below the freezing-point; but a little agitation is sufficient to change it into ice. Sea-water, and in general all salt water, freeze with greater difficulty, because the salt and other ingredients retain the caloric longer. Salt is, moreover, separated in the process of freezing, and precipitated to the bottom, so that ice from sea-water sometimes affords water which is fit for drinking.

The more severe the cold, the greater the hardness and firmness of the ice; and the ice of the polar regions can hardly be broken with a hammer. In the severe winter of 1740, a house was built at Petersburg, from the ice of the Neva, fifty-two feet and a half long, sixteen and a half wide, and twenty high; and notwithstanding the enormous weight of the roof, which was likewise of ice, the lower parts of the building did not receive the smallest injury. The pieces of ice were hewn to the form and shape required, adorned, and arranged according to the rules of architecture. Before the edifice stood six cannons of ice, which were turned in a lathe, with the carriages and wheels of ice, and two mortars formed like cast pieces. The cannons were six-pounders, which are commonly loaded with three pounds of powder; these, however, were loaded with only a quarter of a pound, and carried a ball of stuffed hemp, and sometimes of iron. The balls, at a distance of sixty paces, passed through a board two inches in thickness: the ice of the cannons could not have been much more than three or four inches in thickness, and yet it resisted the force of the explosion.

ICE-HILLS are a species of structure common upon the river Neva, at St. Petersburg. They are constructed in the following manner:—A scaffolding is raised upon the river about thirty feet in height, with a landing-place on the top, the ascent to which is by a ladder. From the summit a sloping plane of boards, about four yards broad and thirty long, descends to the superficies of the river: it is supported by strong poles gradually decreasing in height, and its sides are defended by a parapet of planks. Upon these boards are laid square masses of ice, about four inches thick, which, being first smoothed with the axe, and laid close to each other, are then sprinkled with water: by these means they coalesce, and, adhering to the boards, immediately form an inclined plane of pure ice. From the bottom of this plane the snow is cleared away for the length of 200 yards upon the level bed of the river, and the sides of this course, as well as the sides and top of the scaffolding, are ornamented with firs and pines. Each person, being provided with a sledge, mounts the ladder; and, having attained the summit, he seats himself upon his sledge at the upper extremity of the inclined plane, down which he suffers it to glide with considerable rapidity, poising it as he goes down, when the velocity acquired by the descent carries it above 100 yards upon the level ice of the river. At the end of this course, there is usually a similar ice-hill, nearly paralled to the former, which begins where the other ends, so that the person immediately mounts again, and in the same manner glides down the other inclined plane of ice. The boys also are continually employed in skating down these hills; they glide chiefly upon one skate, as they are able to poise themselves better on one leg than upon two. These ice-hills exhibit a pleasing appearance upon the river, as well from the trees with which they are ornamented as from the moving objects which at particular times of the day are descending without intermission.

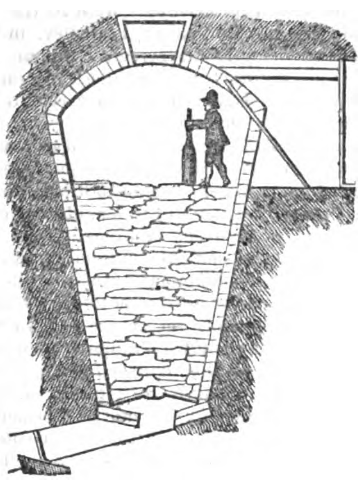
ICE-HOUSE. The preservation of ice, as an article of luxury, is less attended to in this country than in any other part of Europe; we propose, therefore, in the present article, pointing out the mode of constructing an ice-house by which it may be preserved at all seasons, and at a comparatively small expense.

The best soil for an ice-pit to be made in is chalk, as it conveys away the waste water without any artificial drain; and next to that a loose stony earth, or gravelly soil, is the most advantageous. The site should be elevated, that there may be a sufficient descent to convey off any wet that may happen to enter, or from the ice melting; and it should be as much exposed to the air as possible; not under a fall of water, or in the shade of trees, as is too often the practice, under the supposition that if exposed to the sun the ice will melt away in the summer.

The external shape of the building may be according to the convenience of the owner; but, for the well into which the ice is put, a circular form is the most convenient, the depth and diameter of it being proportioned to the quantity of ice wanted; but it is always best to have sufficient room, as, when the house is well built, it will keep the ice two or three years.

Where the quantity wanted is not great, a well of six feet diameter, and eight feet deep, will be large

enough; but, for a large consumption, it should not be less than nine or ten feet in diameter and as many deep: where the situation is either of a dry chalky, gravelly, or sandy kind, the pit may be made entirely below the surface of the ground; but in strong loamy, clayey, or moist ground, it will be better to raise it so high above the surface as that there may be no danger from the wetness of the soil about it. The accompanying engraving represents a well of small cost, but well fitted for its intended object.



At the bottom of the well there should be a space about two feet deep left, for receiving any moisture that may drain from the ice, and a small under-ground drain should be laid from this, to carry off the wet; over this space should be placed a strong grate of wood to let the moisture fall down, which may at any time happen, from the melting of the ice. The sides of the well must be walled up with brick or stone, at least two feet thick; but if it be thicker it will be better, as the thicker the walls are made the less danger there is of the well being affected by external causes. When the wall of the well is brought within three feet of the surface, there must be another outer arch or wall begun, which must be carried up to the height of the top of the intended arch of the well; and, if there be a second arch turned over this, the house will be so much the better; but this must depend on the resources of the person who builds. When complete, the plate into which the roof is to be framed must be laid on the outer wall, which should be carried high enough above the inner arch to admit of a door way for reaching the ice. Where the building is to be covered with slate or tiles, there should be a thickness of reeds, straw, or other similar materials laid under, to guard against the effects of the sun and external air; where they are laid two feet thick, and plastered over with lime and hair, there will be no danger of the heat penetrating in such a way as to prove injurious. The door to enter by, for taking out the ice, should be no larger than absolutely necessary for that purpose, and must be strong and close, to exclude the air; and, at five or six feet distance from this, another door should be contrived, which should be shut before the inner door is opened, whenever the ice is taken out of the house.

In the choice of the ice, the thinnest should be selected: indeed, the smaller it is broken the better, as it will the more readily unite when put into the well. In putting it in, the ice should be rammed close, and a space left between it and the wall of the well, by placing straw for that purpose, so as to admit the passage of any moisture that may be collected by the partial melting of the frozen water.

ICONOGRAPHY; the representation of statues, busts household gods, mosaic works, and pictures in water-colours. Michael Angelo and Ursinus were the restorers of this art, which was carried farther by John Angelus Canini and Bernard de Montfauçon. Canini published his Iconography at Rome, in 1669 (1 vol. 4to.), and Montfauçon the *Antiquites Expliquées*. The latest work of this kind is Visconti's *Iconographie Ancienne* (Paris, 1808—23, 6 vols. 4to.); it contains the portraits of the princes and celebrated men of antiquity. Three volumes form the *Iconographie Grecque;* the following the *Iconographie Romaine;* the fifth volume was published, in 1821, by A. Mongez; the sixth volume concludes the whole.

IDEAL, in the *fine arts*, is distinguished from the exact imitation of reality, by avoiding the imperfections which always disfigure the individual, and giving to each excellence its highest perfection. Imagination creates ideals, in the fine arts, by abstractions from individual forms, separating the individual and casual from the general and the essential, and thus producing ideals of a particular kind. If it performs the same process on these, again abstracting the general and essential, it creates new ideals of a still higher kind; and, if this abstraction is carried on farther, we arrive at last at the pure ideal, which is incapable of any farther separation and generalization—the ideal form of the whole genus. Thus man creates forms elevated above the real forms of nature: we do not say above nature itself, because we understand by nature not only the actual appearances of the sensible world, but also the laws and prototypes which lie at their foundation, and at which imagination arrives in the way indicated. As in thousands of crystals we do not find one which forms a perfect mathematical figure, while the effort of nature to produce such a figure is obvious in all, so is it with the beautiful. All the individual instances may be regarded as the imperfect attempts of nature to produce a faultless model.

In creating the ideal of beauty, man does not follow, as some suppose, the arbitrary suggestions of fancy, but strives to discover and present the prototypes of nature. Imagination finds the materials of the ideal in reality, but she unites the separate traits of the grand and the beautiful, dispersed through nature in one perfect ideal. So, too, there may be ideals of the hateful, the horrid, the malignant; for the ideal aims merely at completeness, whether in the good or the bad, the grand or the mean, the graceful or the ugly, the heroic or the ridiculous. Dante often gives us the ideal of physical suffering; whilst the Koran aims to present the ideal of sensual enjoyment. The caricature is, under a certain point of view, an ideal. The characteristic, which is founded on the deviation of the individual form from the generic, is therefore opposed to the ideal, which loses by any deviation from the generic form; but, on the other hand, the representation gains in character, and thus satisfies the claims of the fine arts, which require not only the beautiful, but the true. Truth must in

no case be sacrificed to beauty. A medium must therefore be employed, by which the truth may be represented as beautiful. This medium is the true ideal of the intuitive arts. Genius only can decide how far the characteristic and the generic are to be mingled.

IDIOSYNCRACY means the peculiar effect produced by certain agents upon the bodily frame; or the peculiar, and frequently morbid state of feeling, of liking or dislike which a person has, with regard to certain objects, whether physical or intellectual.

IGNIS FATUUS. A very interesting description of this curious natural phenomenon, which is seen in the neighbourhood of lakes and stagnant pools, has lately been published in the *Edinburgh New Philosophical Journal;* and the author, Mr. Blesson, has investigated the matter with such care and accuracy as to warrant our quoting the description in his own words.

"The first time," says Mr. Blesson, "I saw the ignis fatuus was in a valley in the forest of Gorbitz, in the New Mark. This valley cuts deeply in compact loam, and is marshy on its lower part. The water of the marsh is ferruginous, and covered with an iridescent crust. During the day, bubbles of air were seen rising from it, and in the night blue flames were observed shooting from and playing over its surface. As I suspected that there was some connection between these flames and the bubbles of air, I marked during the day-time the place where the latter rose up most abundantly, and repaired thither during the night; to my great joy I actually observed bluish-purple flames, and did not hesitate to approach them. On reaching the spot they retired, and I pursued them in vain; all attempts to examine them closely were ineffectual. Some days of very rainy weather prevented farther investigation, but afforded leisure for reflecting on their nature. I conjectured that the motion of the air, on my approaching the spot, forced forward the burning gas, and remarked that the flame burned darker when it was blown aside; hence I concluded that a continuous thin stream of inflammable air was formed by these bubbles, which, once inflamed, continued to burn, but which, owing to the paleness of the light of the flame, could not be observed during the day.

On another day, in the twilight, I went again to the place, where I waited the approach of night: the flames became gradually visible, but redder than formerly, thus showing that they burnt also during the day: I approached nearer, and they retired. Convinced that they would return again to the place of their origin when the agitation of the air ceased, I remained stationary and motionless, and observed them again gradually approach. As I could easily reach them, it occurred to me to attempt to light paper by means of them; but for some time I did not succeed in this experiment, which I found was owing to my breathing. I therefore held my face from the flame, and also held a piece of cloth as a screen; on doing which I was able to singe paper, which became brown-coloured, and covered with a viscous moisture. I next used a narrow slip of paper, and enjoyed the pleasure of seeing it take fire. The gas was evidently inflammable, and not a phosphorescent luminous one, as some have maintained. But how do these lights originate? After some reflection, I resolved to make the experiment of extinguishing them. I followed the flame; I brought it so far from the marsh that probably the thread of connection, if I may so express myself, was broken, and it was extinguished. But scarcely a few minutes had elapsed when it was again renewed at its source (over the air-bubbles), without my being able to observe any transition from the neighbouring flames, many of which were burning in the valley. I repeated the experiment frequently, and always with success. The dawn approached, and the flames, which to me appeared to approach nearer to the earth, gradually disappeared.

On the following evening I went to the spot and kindled a fire on the side of the valley, in order to have an opportunity of trying to inflame the gas. As on the evening before, I first extinguished the flame, and then hastened with a torch to the spot from which the gas bubbled up, when instantaneously a kind of explosion was heard, and a red light was seen over eight or nine square feet of the marsh, which diminished to a small blue flame, from two and a half to three feet in height, that continued to burn with an unsteady motion. It was therefore no longer doubtful that this ignis fatuus was caused by the evolution of inflammable gas from the marsh."

IGNITION (glowing heat) denotes that state of certain bodies in which, from being exposed to a high temperature, they appear luminous. Two kinds of ignitible bodies are distinguished: namely, such as become entirely changed by ignition, as charcoal, sponge, &c.; and such as retain their former state, as iron, for example. The first is a regular combustion, in which, however, no gas rises from the bodies in the form of flame. The second is mere heat. Of the metals, many liquefy before they become ignited: for example, lead and tin. Iron, on the other hand, becomes ignited long before it melts. Three stages of ignition may easily be distinguished. Iron, at about 770° of Fahrenheit, becomes brownish-red, which is the commencement of ignition. At a higher temperature, it becomes red hot; at about 1000° of Fahrenheit, it becomes white hot, and emits a very white brilliant light. If gradually cooled, ignition diminishes in the same inverse order. In this gradual transition, we perceive all the different colours of light.

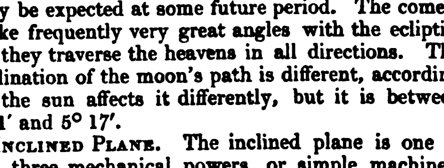
IMPRESSION, in the arts, is used to signify the transfer of certain figures by pressure from a hard to a soft substance. This transfer affords the means of multiplying copies, and takes place in typography, copper-plate printing, lithography, &c. Engravers in copper and wood work in plain surfaces; the gem and stamp engravers, however, produce elevated or sunk figures; consequently, the impressions appear in relievo, and the substances which receive them must be susceptible of being raised or depressed. In order to obtain impressions from copper-plates, a colouring substance must be put in the incisions of the plate. In the case of wood-cuts, the colouring matter is applied to the elevations. In both cases, the copy is procured by pressure.

There are two kinds of impressions:—1. That executed upon plane surfaces, as in lithography, copper-plate printing, and copies from wood-cuts. The instruments for it are the printing, rolling, and lithographic press. The goodness of the copies depends partly on the care and skill of the printer; partly also on the degree in which the plate has been used. The best copies are always among the first hundred. These are sold at a higher price than the subsequent

impressions. An engraved plate affords more good copies than an etched one, and this more than one in aqua tinta. Copies are taken from wood-cuts in the same way as from copper-plates, only the ink is applied to the surface of the figure as in typography. 2. Copies in relievo are impressions of medals and gems, or stamps, so as to leave raised or sunken figures. Medals and engraved gems are valuable as historical monuments and works of art, and the mode in which copies of them are made is a matter of importance. Representations of them in copper-plate engravings cannot properly express their character as works of art. Impressions are therefore taken immediately from them, by means of fine sealing-wax, sulphur, wax, glass, &c. Copies in vitreous substances are called *pastes*.

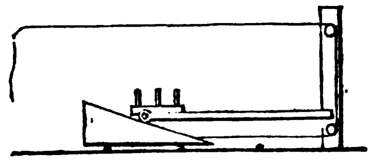
Inclination, in *mathematics*, means the direction of a line, with regard to a certain point (according to the sense of the ancient mathematicians, Apollonius and Pappus particularly). In astronomy, this word signifies the angle which the orbits of the planets and comets make with the ecliptic or orbit of the earth. This angle is the smaller, the less the planet or comet is distant from the ecliptic. According to the latest observations of Lalande and Bode, this angle of inclination is, in the different planets, as follows:—Mercury 7°, Venus 3° 23′ 20″, Mars 1° 51′ Pallas about 30°, Ceres 10° 47′, Jupiter 1° 19′ 10″, Saturn 2° 30′ 20″, Uranus 0° 43′ 45″. More exact determinations with regard to Ceres, Pallas, Juno, and Vesta may be expected at some future period. The comets make frequently very great angles with the ecliptic, for they traverse the heavens in all directions. The inclination of the moon's path is different, according as the sun affects it differently, but it is between 5° 1′ and 5° 17′.

Inclined Plane. The inclined plane is one of the three mechanical powers, or simple machines, formed, as its name imports, by a plane surface, supposed to be perfectly hard and inflexible, and which is always inclined obliquely to the weight or resistance to be overcome. The wedge is a modification of this machine, being formed of two inclined planes placed base to base. The screw is another modification, being, in fact, merely an inclined plane wound round a cylinder. This machine enables us to raise a given weight along the inclined surface to a given elevation, with less expense of force than would be required to raise it perpendicularly to the same elevation. The perpendicular height is called the *elevation of the plane*, and the two lines enclosing the angle which it subtends are called the *base* and the *length* of the plane.



There are two modes of exhibiting the power of the inclined plane. The arrangement exhibited above consists of three paths, inclined to the plane of the horizon at different angles. To carry a loaded carriage up the first would require a weight of one pound, the second two pounds, and the steepest plane three pounds. If the inclined path be three times the length of the perpendicular lift, it will require only one-third the weight to raise the carriage, but then it will require three times as long to accomplish the work.

In the second arrangement of the inclined plane, the mechanical advantage is precisely the same, but the plane itself is put in motion. This is in reality the operating power in a common screw.



Indeterminate Problem and Analysis, in *algebra*; that which admits of innumerable solutions. In such cases, the number of unknown quantities concerned is greater than the number of conditions, or equations, by which they are to be found, whence it happens that some other quantities are assumed to supply the defect. Diophantes was the first writer on this subject, and the result of his labours was published by Xylander in 1575. Mr. Leslie has given an ingenious paper on the solution of indeterminate problems in the second volume of the *Edinburgh Philosophical Transactions*.

Indigo. The knowledge of this most valuable vegetable substance, which forms an important part of East and West Indian commerce, and is beginning to receive considerable attention as a domestic production, is alike interesting to the chemist and to the dyer. The ancients were acquainted with it under the name of *indicum*. Pliny knew that it was a preparation of a vegetable substance, though he was ignorant of the plant which furnished it, and of the process by which it was prepared. From its colour, and the country from which it was imported, some authors call it *atramentum indicum*, and *indicum nigrum*. The American name is *nil*, or *anil*, from which the Portuguese have adopted their *anileira*, the other European nations generally call it *indigo*.

In treating of indigo, it will be the most convenient to explain, in the first place, its physical and chemical properties, and afterwards to allude to the sources from which it is derived, and the method by which it is manufactured. As it is found in commerce, it presents the form of little square or oblong cakes, of an intense blue colour, approaching to black; is brittle and friable; rather light, and without taste or odour. When heated, it has a disagreeable odour, subliming at 55° F.,—a degree of heat near that at which it is decomposed. Its vapour is of a rich violet red-colour, and condenses by cold into delicate acicular crystals, which consist of perfectly pure indigo. Water, by being boiled on indigo, dissolves only about a ninth or a twelfth its weight; the solution is of a reddish-brown colour, and contains what may be called the *extractive* part or the substance; but the colouring matter remains unaltered, except in having assumed a brighter hue. Alcohol and ether, when digested upon it, are also attended with similar effects. Sulphuric acid is the only single agent that dissolves indigo without destroying its colour. When it is put into this acid, a yellow solution is at first formed, which, after a few hours, acquires a deep blue colour. From the solution, diluted with water, potash and its sulphate throw down a deep dark-

blue precipitate, capable of imparting to water, containing only $\frac{1}{300000}$ of its weight, a distinctly blue tinge. It is no longer subject to vaporization, however; from which circumstance, and its property of solubility in water, it is inferred to be a different substance from indigo, and has received the name of *cerulin*. When properly diluted with water, it forms the *liquid blue*, or *Saxon blue*, of the dyers.

Another compound of indigo and water, under the name of *phenecin*, is obtained when water is added to a solution of indigo in sulphuric acid, which has been suffered to stand for several hours, till it has lost its yellow colour, and become blue. It appears to consist of one equivalent of indigo and two of water. In the formation of these substances, indigo is conceived to combine with water; but whether the effect is produced by the sulphuric acid, or whether the sulphuric acid operates merely to prepare the indigo for combining with water afterwards, is not yet fully determined. When indigo, suspended in water, is brought into contact with certain deoxidizing agents, it is deprived of a part of its oxygen, becomes green, and is rendered soluble in water, and still more so in the alkalies. It recovers its former colour, however, on exposure to the air, by again absorbing oxygen of $\frac{1}{7}$ or $\frac{1}{8}$ of the whole weight of the resulting indigo. Its deoxidizement is effected either by allowing it to ferment along with bran, or other vegetable matter, or by decomposing in contact with it the proto-sulphate of iron, by the addition of lime. Substances dyed by deoxidized indigo receive a green tint at first, which becomes blue by exposure to the air. This is the usual method of colouring cloth by means of indigo, which, when fully oxidized, affords a permanent dye, not removable by soap or by acids.

Chlorine, whose power in extinguishing vegetable colours is universal, destroys the colour of indigo; and, from the known fact that a given quantity of free chlorine discolours always the same quantity of pure indigo, a solution of indigo in sulphuric acid has been employed for measuring the strength of solutions of chlorine and of chloride of lime, in order to regulate their application to the art of bleaching; and, reciprocally, a solution containing a known quantity of chloride of lime may be employed as a test of the strength or value of indigo. Indigo may be said to be a rare production of the vegetable kingdom, it hitherto having been found only in a small number of species belonging to the genera *indigofera*, *isatis*, and *nerium*; but it is almost exclusively from the first of these that the indigo of commerce is extracted. In describing the culture of the indigo plant, and the mode of manufacturing the indigo, we shall draw our materials mainly from the methods pursued in the East Indies, where this article is prepared in its greatest perfection. The plant requires a rich, light soil, and a warm exposure. It succeeds best on newly-cleared lands, on account of their moisture; it requires protection against high winds, and needs irrigation in times of drought. The ground, after being properly prepared for the reception of the seed by ploughing, is sown pretty thickly, the time of sowing being so chosen that rain may fall upon the plant as soon as it shows itself above the ground, by which it is not only greatly invigorated, but cleansed from those innumerable insects which otherwise are liable to destroy it. From this time, comparatively little rain is needed; for the dews are so copious as to supply nearly all the moisture required; and, besides, its spindle-shaped root, which descends into the ground perpendicularly, to the depth to nearly three feet, enables it to endure temporary droughts. The prevalence of cloudy weather and much moisture, however, cause the indigo plant to thrive more luxuriantly, but occasion a great deficiency in the colouring matter, which, as it contains an extraordinary quantity of carbon, requires the plant to decompose carbonic acid gas very abundantly,—an operation which it is unable to perform when deprived of the direct influence of the sun's rays. As the young shoots furnish larger and more numerous leaves, it is usual to plant every year; but the Egyptians, who seem to cultivate it most successfully, plant only every third or fourth year. As the plant approaches to maturity, the leaves undergo a sudden change in colour, from a light to a dark green. As soon as this change is observed, the branches are severed from the parent stem early in the morning, and spread out in the sun till the afternoon, by which time they become sufficiently dry to be beaten from the branches by a stick. The leaves, so separated, are housed in warehouses, closely packedand well trodden down by natives. The plants from which the leaves have been severed send forth a new crop, which is gathered, when mature, like the first. Rain, however, is necessary after the cutting, to enable the plant to shoot again in a thriving manner. The cuttings, in a favourable season, are repeated three or four times, after which the ground is ploughed up for another sowing; but each successive growth of the branches produces an increased deterioration of the qualities of the leaves, so that one part of the leaves of the first cutting yields as much indigo as two parts of the third crop.

The dried leaves are not immediately used, but are kept packed for one month, during which time they suffer a material change, which is indicated by their having passed to a light lead-colour. By additional keeping, the lead-colour gradually darkens, until it becomes black. The maximum quantity of indigo is to be obtained when the lead-colour is effected; and any delay in extracting it, after it has reached this point, is attended with a loss in the quantity of the indigo. The lead-colour, however, does not appear in a month after the leaves are gathered, unless, from fear of rain, or any other cause, they were cut before being ripe; and, on the other hand, if the cutting was deferred till after the plant was fully ripe, the leaves will not require to be kept so long. The dried leaves, after having suffered the change of colour alluded to, are transferred to the steeping-vat (an uncovered reservoir, thirty feet square, and twenty-six inches deep, constructed of brick, and lined with stucco), where they are mingled with water, in the proportion of about one volume of leaves to six of water, and allowed to remain two hours. The great affinity of indigo for oxygen is here very manifest, in the quick change of the colour of the leaves which float on the surface, and are exposed to the action of the atmosphere, to a blackish-blue, when contrasted with those below, which remain unchanged. On this account the vat is frequently stirred, so that the floating leaves may be immersed. After two hours' infusion, the water, which, from the solution of imperfectly oxygenized indigo, has acquired a fine green colour, is allowed to run off from the leaves, through straners, into the beating-vat, where it is agitated by the paddles of ten or twelve

people, being obliged to contend, without discipline, against well-trained troops, adopted the irregular mode of fighting, protected by trees or other objects, being, at the same time, mostly skilful marksmen. The efficiency of this method of fighting was evident; and when, in 1791, the French revolutionary war began, the French sent swarms of *tirailleurs* against the allies, and injured them exceedingly. In the wars from 1791 to 1802, the French greatly improved this mode of fighting, which, in the interval of peace that followed, was reduced to a system, the consequences of which were seen in 1805, 1806, and 1807, against the Austrians, Prussians, and Russians. These nations, after the disasters which they suffered, adopted the same system, as well as the greater use of columns, particularly as the ordinary mode of arranging the troops before they came into the fire. Under equal circumstances, well-trained infantry is generally successful against any other kind of troops.

INFLUENZA; a term used in *medicine* to denote an epidemic catarrh which has, at various times, spread more rapidly and extensively than any other disorder. It has seldom occurred in any country of Europe, without appearing successively in every other part of it. It has sometimes apparently traversed the whole of the eastern continent, and in some instances has been transferred to America, and has spread over this continent likewise. The French call it *la grippe*. In all the known instances of its occurrence from the fourteenth century, its phenomena have been pretty uniform, and have differed little, except in severity, from those of the common febrile catarrh. In 1802, such an influenza attracted universal attention. In February it set out from the frontiers of China, traversed all Russia, extended along the Baltic, to Poland and Denmark, reached Germany and Holland in April and May, and France and Spain in June. It could even be followed to Gibraltar. No sex, age, or state of health was exempted. It showed itself chiefly as a severe cold, attended with a catarrhal fever of a more or less imflammatory or bilious character. Generally, it passed over within a few days, yet, in some places, it gave a check to business. Few persons died of it, except those who were afflicted at the same time with other diseases, but almost every one was attacked. G. F. Mort, a German physician, attempted to prove that Europe suffered periodically from the influenza. He maintained that, during the greater part of the period which had elapsed since 1712, this epidemic had visited Europe at intervals of about twenty years, and still more frequently in the early part of the period. Accordingly, he prophesied a new one for 1820, which, however, did not happen.

The epidemic which commenced in the month of February of the present year (1833) may be considered as one of the most rapid and dangerous instances of influenza which has ever appeared. More persons fell victims to its insidious attacks in the metropolis than were destroyed in a similar time by the cholera. Not that the influenza was in itself a mortal ailment to persons previously in good health; but it developed, and brought into active operation, almost every disease which might previously have been considered of a constitutional character.

INGOT, in *the arts*, is a small bar of metal, made of a certain form and size, by casting it in moulds. The term is chiefly applied to the small bars of gold and silver intended either for coining or exportation to foreign countries.

INJECTIONS belong partly to surgery and partly to anatomy. In surgery, fluids, differing according to the different effects desired to be produced, are thrown by means of a small syringe into the natural cavities of the body, or those occasioned by disease, partly to remove unhealthy matter, and partly to bring the remedy immediately to the seat of the disorder, and thus effect a cure. Wounds and sores are usually cleansed in this way, when they extend far below the skin, or an excitement and cure are produced by the same method. Cato the Censor had one applied to himself when he suffered from a fistula. In diseases of the nose and the cavities connected with it, in those which have their seat in the neck, in disorders of the ears, the bladder and urethra, the uterus and vagina, and for the radical cure of hydrocele, injections are often used, and with important advantages. Pure warm water is injected, with the highest success, for the removal of pus, blood, or even foreign bodies. Sometimes astringent medicines to restrain excessive evacuations, sometimes stimulating ones to excite inflammation, as in hydrocele, or even to increase and improve evacuations, sometimes soothing medicaments to mitigate pain, &c., are added to the water. In diseases of the throat which hinder the patient from swallowing, and thus tend to produce death by starvation, nourishing fluids are injected into the stomach.

The blood of beasts, or of men, has been sometimes injected into the veins, which is called *transfusion*. In the same way medicines are introduced immediately to the blood; for instance, tartar emetic to excite vomiting, if a foreign body is fixed in the throat so firmly as to restrain the patient from swallowing, and can neither be moved up nor down. According to the place where the injection is to be made, the instrument must be either longer or shorter, a straight or a curved tube. The size is regulated by the quantity of the liquid to be injected, and the force which is to be applied. Anatomists inject into the vessels of bodies various coloured fluids, which are liquid when hot, and coagulate when cold, to make the smaller ones visible. Thus the arteries, veins, and lymphatic vessels are injected. Anatomy has carried this art so far as to make very minute vessels visible to the naked eye. (See TRANSFUSION.)

INK, WRITING. This material can be prepared of various colours, but black is the most common. Doctor Lewis gives the following recipe:—In three pints of white wine, or vinegar, let three ounces of gall-nuts, one ounce of powdered logwood, and one ounce of sulphate of iron, be steeped half an hour; then add one ounce and a half of gum-Arabic, and, when the gum is dissolved, pass the whole mixture through a hair-sieve. Van Mons recommended the following preparation:—Let four ounces of gall-nuts, two ounces and a half of sulphate of iron calcined to whiteness, and two pints of water, stand in a cool place twenty-four hours; then add one ounce and a quarter of gum-Arabic, and keep it in a vessel open, or slightly stopped with paper. Another recipe is this:—Take one pound of gall-nuts, six ounces of gum-Arabic, six ounces of sulphate of iron, and four pints of beer or water. The gall-nuts are broken, and stand as an infusion twenty-four hours; then coarsely-pounded gum is added, and suffered to dissolve; lastly, a quantity of sulphate of iron is introduced, and the whole passed through a hair-sieve. It is generally observed that unboiled inks are less

good red ink is obtained as follows.—A quarter of a pound of the best logwood is boiled with an ounce of pounded alum, and the same quantity of cream of tartar, with half the quantity of water, and, while the preparation is still warm, sugar and good gum-Arabic, of each one ounce, are dissolved in it. Solutions of indigo with pieces of alumina, and mixed with gum, form a blue ink. Green ink is obtained from verdigris, distilled with vinegar and mixed with a little gum. Saffron, alum, and gum-water, form a yellow. It is not well ascertained how soon the present kind of writing-ink came into use. It has certainly been employed for many centuries in most European countries; but the ancient Roman inks were, for the most part, of a totally different composition, being made of some vegetable carbonaceous matter, like lamp-black, diffused in a liquor. Sometimes the ink of very old writings is so much faded by time as to be illegible. Doctor Blagden (*Philosophical Transactions*, vol. 77), in his experiments on this subject, found that, in most of these, the colour might be restored, or, rather, a new body of colour given, by pencilling them over with a solution of prussiate of potash, and then with a dilute acid, either sulphuric or muriatic; or else, *vice versâ*, first with the acid, and then with the prussiate.

INLAND NAVIGATION. A general account of CANAL NAVIGATION has already been given under that head; and a view of river navigation will appear under RIVERS. We now purpose giving a general view of the canals in Canada. Those of the United States of America will be noticed in their several geographical divisions, as they are too numerous to be brought into one article.

Welland Canal was constructed between the years 1824 and 1829. Its length is forty-one miles and a half; its breadth at the surface fifty-eight feet, at the bottom twenty-six feet, and its depth eight feet. This line of navigation passes from the mouth of Ouse River, on Lake Erie, north-eastward, to strike at a point of the Welland or Chippewa River; and, taking the course of that river, downwards, eleven miles, proceeds thence northward, across the mountain ridge, and down to the mouth of Twelve-Mile Creek, on Lake Ontario. The distance from lake to lake is forty-three miles. The deepest cutting, near the summit, is fifty-six feet. It has thirty-five locks, one hundred to one hundred and twenty-five feet long, twenty-two to thirty-two feet wide. The capital stock of the company is 200,000*l.*; the number of shares 16,000. This canal admits of sloop navigation, and opens a communication between Lake Erie and Lake Ontario in the same vessels, which are thus enabled to navigate those lakes without discharging and reloading cargoes. One of the purposes of its construction was, to prevent the trade of that part of Upper Canada which communicates with the great western lakes from being diverted to New York, by the route of the Erie Canal. It was an arduous and stupendous work, as appears sufficiently from the dimensions and length of the canal. Its execution was, however, facilitated by taking advantage of natural channels of slack-water.

La Chine Canal is ten miles in length, from Montreal, on the St. Lawrence, directly to Upper La Chine, on Lake St. Louis, cutting off a bend in the river, and avoiding the rapids of St. Louis. Cost, 220,000*l.*; for sloop navigation.

L'Isle Perrault Canal is a projected work of five miles in length, from St. Louis Lake, at the foot of St. Anne's rapids, to the head thereof, by a canal, passing either at the back of St. Anne's or else across the Isle Perrault.

Grenville Canal is a projected work of twelve miles in length, from the head of Long Sault, or Ottawa falls, at the village of Grenville, by a lateral canal to the foot of Carillon rapids, opposite Point Fortune; for sloop navigation. Estimated cost, 250,000*l.*

La Petite Nation Canal is a projected artificial channel of navigation, of fifty miles in length, from the foot of Carillon rapids, at Hawkesbury, on the Ottawa, across the peninsula, to the St. Lawrence, at Prescott.

The *Rideau Canal*, which is now just completed, is described, and a view of its locks given, under the cut CANADA, in the Second Division of this work.

INSTRUMENT, in *music*; any sonorous body, artificially constructed for the production of musical sound. Musical instruments are divided into three kinds—wind-instruments, stringed instruments, and instruments of percussion. Of the stringed instruments among the ancients, the most known are the lyre, psalterium, and trigonium; the principal wind-instruments are the tibia, fistula, tuba, cornu, and lituus; those of percussion, the tympanum, cymbalum, and crepitaculum.

INSTRUMENTAL MUSIC; music produced by *instruments*, as contradistinguished from vocal music. The term *instrumental* is particularly applied to the greater compositions, in which the human voice has no part. The first instrument invented was probably the pipe or flute. An idle shepherd might very naturally, from accident, or in imitation of the effects of the wind, blow through a simple reed, and thus invent the pipe, from which the flute would readily originate. The pipe is, in fact, found among many savages. The invention of stringed instruments, as they are more artificial, is of later origin. The instrumental music of the Greeks was confined to a few instruments, among which the flute, the cithara, the sackbut, though not precisely like those instruments among the moderns, were the most important. The violin was invented in the middle ages, and soon became the principal instrument, taking place above the flute, though the latter is of much more ancient origin, because the playing on a stringed instrument is less fatiguing, and the tone of the violin is more distinct from the human voice, and therefore better fitted to be used with it; besides, the instrument permits much more perfect execution. Until the middle of the last century, the Italian composers used no other instruments in their great pieces than violins and bass-viols; at that time, however, they began to use the hautboy and the horn; but the flute has never been much esteemed in Italy, particularly in music exclusively instrumental. These were the only wind-instruments in Italy, used in instrumental music, until the end of the last century; and even to this day the Italians use wind-instruments much less than the Germans, and particularly the French. Since Mozart, every instrument has been used which appeared adapted to answer a particular purpose. This is the cause of the fewness of the notes in the Italian, and of their great number in German, and their excess in the modern French scores. In general, symphonies and overtures, solos, duets, terzettos, quartettos, quintettos, &c., sonatas, fantasias, con-

certos for single instruments, dances, marches, &c., belong to instrumental music.

INSURANCE is a contract whereby, for a stipulated consideration, called a *premium*, one party undertakes to indemnify another against certain risks. The party undertaking to make the indemnity is called the *insurer* or *underwriter*, and the one to be indemnified the *assured* or *insured*. The instrument by which the contract is made is denominated a *policy*; the events or causes of loss insured against, *risks* or *perils*; and the thing insured, the *subject* or *insurable interest*. *Marine* insurance relates to property and risks at sea; insurance of property on shore against fire is called *fire* insurance; and the written contracts, in such cases, are often denominated *fire* policies.

There was a kind of insurance in use among the Greeks and Romans, called *bottomry* or *respondentia*, which is where the owner of a vessel or goods borrows money upon bottomry, upon the vessel, or upon respondentia on the goods, for a certain voyage, agreeing that, if the ship or goods arrive at a certain port, the money shall be repaid, and also interest, exceeding the legal rate; but, if lost by the risks specified in the bond before arriving at the port named, the lender is to lose the money loaned. This risk of losing the whole capital is the cause of the excess of interest allowed in case of the arrival of the ship or goods; and it is called *marine interest*, which ought to be equal to the common rate of interest added to the rate of premium for insuring the ship or goods for the same voyage against the same risks. This sort of contract was anciently in use, and, as the laws then gave less security, or, at least, as credit and confidence were not so widely diffused, and correspondence was less extensive among merchants, it was usual for the lender to send some person with the property, to receive repayment of the money loaned and the marine interest, at the port where the risk terminated. In modern times, it is not usual to send any person with the property, who would not be of service during the voyage; and, at its termination, some agent of the lender, at the port of arrival, if he is not there himself, looks after his interest.

The wide extension of correspondence, among merchants in all parts of the world, in modern times, gives a facility for this purpose, and renders the execution of this, as well as other commercial contracts, more economical, and at the same time more secure. But contracts of insurance, strictly so called, are of modern invention; and their importance, in relation to commerce, is scarcely inferior to that of bills of exchange. Every merchant is liable to losses and reverses, by the change of the markets. The risks of this description may, however, be calculated upon with some degree of probability; but those of fire, the perils of the seas, or capture, cannot be so well estimated; and, when they come, they would, in many cases, bring ruin upon the merchant, if it were not for the system of insurance, the object of which is to apportion the losses from these disasters among all those whose property is exposed to the same hazards. If, for instance, all persons engaged in trading were to enter into a general agreement to contribute for the losses of each other, occasioned by those casualties, in the proportions of the amounts that they should respectively have at risk, every individual would then only run the risk of the proportion of losses occurring upon the general aggregate of property at risk. But as such a general combination would be complicated, and practically inconvenient, a very simple system is devised, by means of insurance, for effecting the same object; for one person—the underwriter—agrees to take upon himself those risks for a hundred merchants, more or less, for a certain premium on each risk, calculating that the premiums on the fortunate adventurers will compensate him for the losses he may incur on those which are unfortunate, and leave him some surplus, as a compensation for his time and trouble; and a little experience will enable him to calculate the chances with very considerable accuracy. The result accordingly is, that all the persons who procure their property to be insured by him, in effect, mutually contribute for each other's losses, by the bargain of each with the common receiver of the contributions of all. This contract was subjected to a system of definite rules much earlier in Italy and France than in England; and, as the contract is the same in principle and very similar in form in different countries, the rules of construction adapted to it in one country are equally applicable in another.

Insurances on human life may now be noticed. The duration of life, over which the most healthy and the most temperate man has no certain control, must necessarily appear a matter of chance when individually considered. If, however, we regard the human species in masses, we are enabled to ascertain with considerable precision the average of life; and thus to apply a system of insurance, not to life itself, for that is, of course, dependent upon a higher power than man, but against the injurious consequences which proceed from the death of those upon whom the support of others depends. If we take ten millions of people, for instance, and ascertain the age to which each person arrived previously to his death, by dividing the total of their ages by the number of individuals, we establish the average term of the duration of life. This term varies in particular countries and under different states of society; but it is invariably found to increase with the increase of the means of comfort. The average term of life in Great Britain is thus longer, by almost one-third, than it was during the last century. The rate of mortality in 1780 was one in forty; in 1821 it was one in fifty-eight. Vaccination, and the great improvements in medical science, have doubtless contributed to this result. To establish data for determining this mean length of life has been an important object with statesmen, of late years, and forms a great branch of the science of statistics. The tables which have been constructed upon the experience of most European nations enable us, not only to determine the average term of life, but the probabilities of the number of years a person of any particular age has to live. Upon these calculations is founded the system of life-assurances and annuities; and the various corporations which grant life-assurances are enabled to conduct their operations upon a just and solid foundation, in proportion as they form their estimates upon averages equally supported by science and experience. To all persons whose income is not permanent, and who are unable to lay by a sufficiency to prevent the lamentable consequences to their children of an inadequate provision, the principle of life-assurance offers a safe and effectual remedy against the chances of mortality, which no prudent father should forego, if the annual sacrifice

be at all within his ability. We subjoin a table of the value of an annuity of 100*l.* on a single life from birth to 70 years of age.

Age.	Value. £.	s.	Age.	Value. £.	s.	Age.	Value. £.	s.
Birth.	1032	14	24	1556	0	48	1168	10
1	1346	10	25	1543	16	49	1147	10
2	1563	6	26	1531	4	50	1126	8
3	1646	4	27	1518	8	51	1105	14
4	1701	0	28	1505	6	52	1084	18
5	1724	16	29	1491	16	53	1063	14
6	1748	4	30	1478	2	54	1042	2
7	1761	2	31	1463	18	55	1020	2
8	1766	4	32	1449	10	56	997	14
9	1762	10	33	1434	14	57	974	18
10	1752	6	34	1419	10	58	951	12
11	1739	6	35	1403	18	59	928	0
12	1725	2	36	1388	0	60	903	18
13	1710	6	37	1371	12	61	879	10
14	1695	0	38	1354	16	62	854	14
15	1679	2	39	1337	10	63	829	2
16	1662	10	40	1319	14	64	803	0
17	1646	4	41	1301	16	65	776	2
18	1630	18	42	1283	16	66	748	16
19	1616	14	43	1265	14	67	721	2
20	1603	6	44	1247	4	68	693	0
21	1591	4	45	1228	6	69	664	14
22	1579	14	46	1208	18	70	636	2
23	1568	0	47	1189	0			

INTAGLIO. See GEM.

INTEREST is the allowance made for the loan or forbearance of a sum of money, which is lent for, or becomes due at, a certain time; this allowance being generally estimated at so much per cent. per annum, that is, so much for the use of 100*l.* for a year. Interest is either *simple* or *compound*. *Simple interest* is that which is allowed upon the principal only, for the whole time of the loan or forbearance. The money lent, or forborne, is called the *principal*; the sum paid for the use of it the *interest*. The interest of 100*l.* for one year is called the *rate per cent.*, and the sum of any principal, and its interest, together, the *amount*. *Compound interest* is that which arises from any sum or principal in a given time, by increasing the principal, at fixed periods, by the interest then due, and hence obtaining interest upon both interest and principal. The accumulation of money, when placed at compound interest, after a certain number of years, is exceedingly rapid, and in some instances appears truly astonishing.

INTERVAL; the difference in point of gravity or acuteness between any two sounds. Taking the word in its more general sense, we must allow that the possible *intervals* of sound are infinite; but we now speak only of those intervals which exist between the different tones of any established system. The ancients divided the *intervals* into simple or uncomposite, which they called *diastems*, and composite intervals, which they called *systems*. The least of all the *intervals* in the Greek music was, according to Bacchius, the enharmonic diesis, or fourth of a tone; but our scale does not notice so small a division, since all our tones concur in consonances, to which order only one of the three ancient genera, viz. the diatonic, was accommodated. Modern musicians consider the *semitone* as a simple interval, and only call those composite which consist of two or more semitones: thus from B to C is a semitone, or simple interval, but from C to D is two half tones, or a compound interval.

INTESTINE. The convoluted membraneous tube that extends from the stomach to the anus, receives the ingested food, retains it a certain time, mixes with it the bile and pancreatic juice, propels the chyle into the lacteals, and covers the fæces with mucus, is so called. The intestines are situated in the cavity of the abdomen, and are divided into the small and large, which have, besides their size, other circumstances of distinction. The small intestines are supplied internally with folds, called *valvulæ conniventes*, and have no bands on their external surface. The large intestines have no folds internally, but are supplied externally with three strong muscular bands, which run parallel upon the surface, and give the intestines a saccated appearance; they have also small fatty appendages, called *appendiculæ epiploicæ*. The first portion of the intestinal tube, for about the extent of twelve fingers' breadth, is called the *duodenum;* it lies in the epigastric region, makes three turnings, and between the first and second flexure receives, by a common opening, the pancreatic duct, and the *ductus communis choledochus*.

It is in this portion of the intestines that chylification is chiefly performed. The remaining portion of the small intestines is distinguished by an imaginary division into the *jejunum* and *ileum*. The *jejunum*, which commences where the *duodenum* ends, is situated in the umbilical region, and is mostly found empty; hence its name: it is every where covered with red vessels, and, about an hour and a half after a meal, with distended lacteals.—The *ileum* occupies the hypogastric region and the pelvis, is of a more pallid colour than the former, and terminates by a transverse opening into the large intestines, which is called the *valve of the ileum*, the *valve of the cæcum*, or the *valve of Tulpius*. The beginning of the large intestines is firmly tied down in the right iliac region, and, for the extent of about four fingers' breadth, is called the *cæcum*, having adhering to it a worm-like process, called the *processus cæci vermiformis*, or *appendicular cæci vermiformis*. The great intestine then takes the name of *colon*, ascends towards the liver, passes across the abdomen, under the stomach, to the left side, where it is contorted like the letter S, and descends to the pelvis; hence it is divided, in this course, into the *ascending portion*, the *transverse arch*, and the *sigmoid flexure*. When it has reached the pelvis, it is called the *rectum*, whence it proceeds in a straight line to the anus.

The intestinal canal is composed of three membranes or coats; a common one from the *peritoneum*, a muscular coat, and a villous coat, the *villi* being formed of the fine terminations of arteries and nerves, and the origins of lacteals and lymphatics. The intestines are attached to the body by the mesentery; the *duodenum* has also a peculiar connecting cellular substance, as have likewise the colon and rectum, by whose means the former is firmly accreted to the back, the colon to the kidneys, and the latter to the *os coccygis*, and in women to the vagina. The remaining portion of the tube is loose in the cavity of the abdomen. The arteries of this canal are branches of the *superior* and *inferior mesenteric*, and the *duodenal*. The veins evacuate their blood into the *vena portæ*. The nerves are branches of the eighth pair and intercostals. The lacteal vessels, which originate principally from the *jejunum*, proceed to the glands in the mesentery.

INTONATION, in *music*, relates both to the consonance and to the strength or weakness of sounds. Intonation not only includes the act of tuning, but the giving to the tones of the voice or instrument that occasional impulse, swell, and decrease, on which, in a great measure, all expression depends. A good intonation is one of the first qualifications in the higher walks of execution.

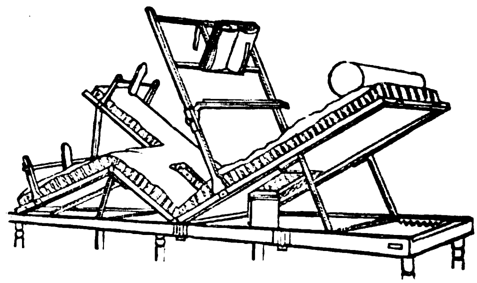
In church music, those antiphonies are called *intonations* which are first sung by the priest, and then responded by the choir or the congregation; also the short sentence, mostly taken from the bible, which the minister sings before the collect, and which is responded by the choir or community. Such are the *Gloria*, "The Lord be with you," &c.

INTOXICATION. See DRUNKENNESS and TEMPERANCE.

INTRENCHMENT; any work that fortifies a post against the attack of an enemy. The word is generally used to denote a ditch or trench with a parapet. Intrenchments are sometimes made of fascines with earth thrown over them, of gabions, hogsheads, or bags filled with earth, to cover the men from the enemy's fire.

INVALIDS; soldiers and officers, who are disabled for foreign service by wounds, disease, or age, and who are generally maintained for life in public establishments (hospitals), at the public expense. The Athenians had a law providing for the public maintenance of persons disabled in war. The Romans also made some, though small, provision for invalids. At a later period, they were taken care of in the monasteries. Philip Augustus of France first formed the plan of an hospital for invalids; but, as Pope Innocent III. would not permit this institution to be placed under the direction of the bishop, the king relinquished the plan. Louis XIV. was the first who carried this design into execution. Between 1671 and 1679, he erected a splendid hospital at Paris, in the suburb of St. Germain. A church, a department for the sick, a governor, and other officers, are attached to it. A soldier must have served ten years to be received into this hospital on account of poverty or infirmity. The invalids who mount guard are the only ones who bear arms. This institution suffered very much at the commencement of the revolution; but, during the imperial government, it was put in a better condition than ever. The architect of the hospital was Bruant. It is composed of five courts surrounded by buildings. A vast esplanade, bordered by rows of trees, and decorated with a fountain, gives the principal *façade*, towards the Seine, a noble perspective. The *hôtel* has a library of 20,000 volumes. It is capable of containing 7000 men, and is governed by a marshal of France. The church is considered a *chef-d'œuvre* of French architecture; its dome supports a lantern, which is surmounted by a cross 308 feet high. From the dome were formerly suspended 3000 colours, taken from different nations; but they were taken down and burnt by the invalids, at the time when the allies entered Paris, that they might not be retaken. Works in statuary and painting, by Lafosse, Boullongne, Coypel, Coustou, Coysevox, &c., adorn the ceilings, niches, and other parts of the buildings. Frederick the Great, in 1748, built the hospital at Berlin, with the inscription *Læso et invicto militi*. Our own hospitals at Greenwich and Chelsea are the best regulated of the kind.

INVALID BED. There are many contrivances under this name, but the one represented beneath seems the best mechanical arrangement for the purpose.



It is the invention of Mr. Earl, and consists of a strong frame supporting a jointed bedstead. The situation of the pillow points out the part of the apparatus which supports the upper portion of the body. The mattress should be either of horse-hair or wool, and nailed round its edges to the upper division of the movable frame.

Another form of bed for an invalid has been suggested by Dr. Arnott. It consists of a trough containing water, and covered with a cloth composed of cotton coated with Indian rubber. This forms one of the softest and most flexible beds that has ever been devised.

INVENTION, in *science*, is distinguished from *discovery*, as implying more creative combining power, and generally signifies the application of a discovery to a certain purpose. But the distinction is often very nice, and it is difficult, in many cases, to say which word is the more suitable. Every invention includes a discovery. Inventions owe their origin, as discoveries do, either to chance, to some happy idea suddenly striking the mind, or to patient reflection and experiment. Many inventions belong to the two former heads. Of the third class of inventions, late years afford many instances, owing to the great attention which has been paid to the natural sciences. As man, in modern times, is always inclined to consider that which is nearest him the most important, he generally considers the inventions of his age as far surpassing those of other times; but the study of history teaches us more modesty. The invention of the screw, of the wheel, of the rudder, of the double pulley, may be compared with any modern inventions in mechanical science, and could not, moreover, have been struck out at once by chance. The history of inventions is one of the most interesting branches of the historical sciences, exhibiting in a striking light the stages of progress and decline in human activity, and the great variety of motives which have actuated different ages.

INVISIBLE GIRL. This curious acoustical exhibition was contrived by a foreigner, about thirty years ago. It consisted of a hollow copper ball, to which were attached four trumpets, and which was suspended by ribands from the four corners of a frame resembling a bed-post, and having no other connection with the frame. The globe was supposed to contain the invisible being, as the voice apparently proceeded from the interior of it. If a question was asked by speaking into one of the trumpets, an answer was returned in a low female voice proceeding from all the trumpets. This effect was produced by one of the standards of the frame being

hollow, opening opposite the mouth of one of the trumpets, and communicating with a large case placed in an adjoining room, and containing the confederate.

Upon this principle also is constructed the *oracular bust*, which is thus made :—Place a bust on a pedestal in the corner of a room, and let there be two tin tubes, one going from the mouth and the other from the ear of the bust, through the pedestal and floor, to an under apartment; there may likewise be wires that go from the under jaw and the eyes of the bust, by which they may be easily moved. A person being placed in the under room, and at a given signal applying his ear to one of the tubes, will hear any question that is asked by another person above who speaks into the ear of the bust, and he may immediately reply; the sound will move through the tube, and seem to come from the mouth of the bust.

INVOICE; an account, in writing, of the particulars of merchandise, with their value, custom, charges, &c., transmitted by one merchant to another in a distant country.

INVOLUTION, in *mathematics;* the raising of a quantity from its root to any power assigned. Thus $2\times2\times2=8$. Here 8, the third power of 2, is found by involution. By continuing the process, we can obtain any power of 2, and so with other numbers.

IODINE is the name of an undecompounded principle or element in chemistry. It had escaped the observation of chemists until 1812, when a manufacturer of saltpetre, at Paris, detected it in the ashes of sea-weeds, in the following manner. In evaporating the ley from these ashes, to procure the carbonate of soda which they contain, he noticed that the metallic vessels with which he operated were powerfully corroded, and that the corrosion was increased as the liquor became more concentrated. Having at hand, one day, a bottle of sulphuric acid, he added some of it to a portion of water, and was surprised to see a rich violet vapour disengaged; this vapour was the iodine. He at once communicated the observation to M. Clément Desormes, who set about collecting some of the vapour, and, after examining its leading properties, announced it to the Royal Institute of France as a new body. Its real nature was soon after unfolded through the accurate researches of Gay-Lussac and Sir H. Davy. Its history proved singularly interesting in modifying the then prevailing theory of chemistry. Sir H. Davy had, a few years previously, promulgated the new theory of chlorine, which was still received with suspicion among chemists. The strong analogies, however, between this substance and chlorine, in their relations to combustibles,—both bodies forming compounds by uniting with them, similar to acids containing oxygen, or oxides,—were conceived to give great weight to the views of Sir H. Davy, and operated completely to overthrow the erroneous hypothesis of oxygenation invented by Lavoisier. Its investigation, therefore, may be said to form a new era in chemistry.

The physical properties of iodine are as follow :—It is a soft, friable, opaque solid, of a bluish-black colour, with a metallic lustre, usually in scales, but sometimes in distinct crystals of the form of rhomboids or rhomboidal tables, referrible to an octahedron, with a rhombic base as their primary form; its specific gravity is 4.046. It possesses an odour somewhat analogous to that of chlorine. It is a non-conductor of electricity, and possesses in an eminent degree the electrical properties of oxygen and chlorine.

Iodine enters into fusion at 225° Fahr., and boils at 347°; but, when moisture is present, it sublimes rapidly at a temperature considerably below 212°, and gives rise to a dense vapour of the usual violet hue. It is scarcely at all soluble in water, but is readily taken up by alcohol and ether, to which it imparts a reddish-brown colour. It extinguishes vegetable colours, but with less energy than chlorine. It is not inflammable. Its range of affinity for other bodies is very extensive; the most important compounds it forms with these we shall describe after alluding to its natural state and preparation. It exists most abundantly in the various species of fucus, which form the greatest part of the sea-weeds of our coast; it also occurs in the sponge, and in the coverings of many molluscous animals, and has been found in a great number of mineral waters, as those of Salz in Piedmont, Saratoga in New York, &c., and more recently has been detected in some silver ores from Mexico, and in an ore of zinc from upper Silesia. But it is from the incinerated sea-weed, or kelp, that the iodine in large quantities is obtained.

As the soap-manufacturers are in the habit of obtaining their soda from kelp, iodine may be procured, very economically, from the residuums of their operation, according to the process invented by Dr. Ure, which is as follows :—The brown iodic liquor of the soap-boiler, or the solution of kelp from which all the crystallizable ingredients have been separated by concentration, is heated to about 230° Fahr., poured into a large stone-ware basin, and saturated with diluted sulphuric acid. When cold, the liquor is filtered through woollen cloth; and to every 12 oz. (apothecaries' measure) of it are added 1000 grains of black oxide of manganese in powder. The mixture is put into a glass globe, or large matrass with a wide neck, over which a glass globe is inverted, and heat is applied, which causes the iodine to sublime copiously, and to condense in the upper vessel. As soon as the balloon becomes warm, another is substituted for it; and, when the second becomes heated, the first is again applied. The iodine is withdrawn from the globes by a little warm water, which dissolves it very sparingly; and it is purified by undergoing a second sublimation. The test made use of for the detection of iodine in any solution, when it is suspected to be present, is starch, with which iodine has the property of uniting, and of forming with it a compound, insoluble in cold water, which is recognized with certainty by its deep blue colour. The solution should be cool at the time of adding the starch; and, if the colour does not become apparent simply on the addition of the starch, a few drops of sulphuric acid should be cautiously added, when, if any iodine be present, the blue colour will make its appearance. This test is so exceedingly delicate that a liquid, containing $\frac{1}{450000}$ of its weight of iodine, receives a blue tinge from a solution of starch.

Iodine has a powerful affinity for hydrogen, which it takes from animal and vegetable substances, in the same manner as chlorine, and, uniting with it, forms hydriodic acid. The following are the methods for obtaining this acid in the gaseous and in the liquid state:—Into a flask, to which a recurved tube is fitted, dipping under a jar of mercury, are introduced eight

parts of iodine and one of phosphorus, and to the mixture a few drops of water are added; the water is immediately decomposed; the phosphorus, seizing its oxygen, forms phosphoric acid, while the hydrogen combines with the iodine. As there is not water present in sufficient quantity to dissolve the hydriodic acid, it passes over in the gaseous state, and is collected over the mercury. In contact with air, it smokes, or fumes, like muriatic acid, and, like it, reddens vegetable blues. It is distinguished, however, from that acid, by the superior affinity possessed by chlorine for hydrogen, in consequence of which, if chlorine and hydriodic gases are mingled together, the yellow colour of the former disappears, and the violet vapour of iodine makes its appearance, which proves the decomposition of the hydriodic acid by the chlorine. If the decomposition be complete, the vessel will be wholly occupied by muriatic acid gas.

To obtain the hydriodic acid in a liquid state, we have only to conduct the gas through water, until it is fully charged with it; or it may be obtained by transmitting a current of sulphuretted hydrogen gas through water in which iodine, in fine powder, is suspended. The iodine, from a greater affinity for hydrogen than the sulphur possesses, decomposes the sulphuretted hydrogen; and hence sulphur is set free, and hydriodic acid produced. The solution of hydriodic acid is easily decomposed. Thus, on exposure for a few hours to the air, the oxygen of the atmosphere forms water with the hydrogen of the acid, and liberates the iodine. Nitric and sulphuric acids likewise decompose it by yielding oxygen, the former being converted into nitrous and the latter into sulphurous acid. The free iodine becomes obvious on the application of the above-mentioned test. The compounds of hydriodic acid with the salifiable bases may be easily formed, either by direct combination, or by acting on the bases in water with iodine. Sulphurous and muriatic acids, as well as sulphuretted hydrogen, produce no change on the hydriodates, at the usual temperature of the air; but chlorine, nitric and concentrated sulphuric acid, instantly decompose them, and separate the iodine. The hydriodates of potash and soda are the most interesting of their number, because they are the chief sources of iodine in nature. The latter salt is probably the one which affords the iodine obtained from kelp; while it is believed that it is the hydriodate of potash which is most generally found in mineral springs.

Iodine forms acids by uniting with oxygen and with chlorine. When it is brought into contact with protoxide of chlorine, immediate action ensues; the chlorine of the protoxide unites with one portion of iodine, and its oxygen with another, forming two compounds,—a volatile orange-coloured matter, the chloriodic acid, and a white solid substance, which is iodic acid. Iodic acid acts powerfully on inflammable substances. With charcoal, sulphur, sugar, and similar combustibles, it forms mixtures which detonate when heated. It enters into combination with metallic oxides, giving rise to salts called *iodates*. These compounds, like the chlorates, yield pure oxygen by heat, and deflagrate when thrown on burning charcoal. Iodic acid is decomposed by sulphurous, phosphorous, and hydriodic acids, and by sulphuretted hydrogen. Iodine, in each case, is set at liberty, and may be detected, as usual, by starch. Chloriodic acid, which is also formed by simply immersing dry iodine in chlorine gas, deliquesces in the open air, and dissolves very freely in water. Its solution is very sour to the taste; and it reddens vegetable blues, but afterwards destroys them. It does not unite with alkaline bases; in which respect it wants one of the characteristics of an acid, and has hence been called by Gay-Lussac a *chloride of iodine*. Iodine unites with nitrogen, forming a dark powder, which is characterized, like chloride of nitrogen, by its explosive property. In order to form it, iodine is put into a solution of ammonia; the alkali is decomposed; its elements unite with different portions of iodine, and thus cause the formation of hydriodic acid and iodide of nitrogen. Iodine forms, with sulphur, a feeble compound, of a grayish-black colour. With phosphorus, also, it combines with great rapidity at common temperatures, attended with the emergence of heat. It manifests little disposition to combine with metallic oxides; but it has a strong attraction for the pure metals, producing compounds which are called *iodurets*, or *iodides*.

The iodides of lead, copper, bismuth, silver, and mercury, are insoluble in water, while the iodides of the very oxidizable metals are soluble in that liquid. If we mix a hydriodate with the metallic solutions, all the metals which do not decompose water will give precipitates, while those which decompose that liquid will give none. Iodine, besides being employed for philosophical illustration, is used in the arts, for pigments, dyes, and medicine.

Iolite. See Mineralogy.

Ionian Order. See Architecture.

Ipecacuanha, according to the latest authorities, is the product of two different plants, both natives of South America. The gray is the root of a species of *richardia*; the other that of the *cephælis ipecacuanha*. The two roots, however, do not differ in their medicinal properties, and they are much employed indiscriminately. Ipecacuanha was first brought to Europe towards the middle of the seventeenth century; but was not generally used till about the year 1686, when it was introduced under the patronage of Louis XIV. Its taste is bitter and acrid, covering the tongue with a kind of mucilage. It is one of the safest and mildest emetics with which we are acquainted, and is administered as a powder, in the tincture, or infused in wine. It is also less injurious, if it does not operate as an emetic, than antimony, from its not disturbing the bowels as that does.

Iridium; the name of a metal discovered in 1803, by Mr. Tennant, in the black residuum from the solution of the ore of platinum. Its name was bestowed in allusion to the rainbow (*iris*), in consequence of the changeable colour it presents while dissolving in muriatic acid. Its colour is white; it is brittle, and very difficult of fusion; specific gravity, 18.68. It is acted upon with difficulty even by the nitro-muriatic acid; but, when oxidized by digestion with it, it unites with other acids, and with the earths, particularly with alumine. It combines with sulphur, by heating a mixture of ammonia, muriate of iridium, and sulphur; the compound is a black powder, consisting of 100 iridium and 33.3 sulphur. Lead unites with this metal easily, but is separated by cupellation, leaving the iridium on the cupel, as a coarse black powder. Copper forms with it a very malleable alloy, which after cupellation, with the addition of lead, leaves a small proportion of the iridium, but much

less than in the preceding instance. Silver forms with it a perfectly malleable compound, the surface of which is merely tarnished by cupellation; yet the iridium appears to be diffused through it in fine powder only. Gold remains malleable, and little altered in colour, though alloyed with a considerable proportion; nor is it separable by cupellation. Dr. Wollaston observed that, among the grains of crude platinum, there are some scarcely distinguishable from the rest but by their insolubility in nitro-muriatic acid. They are harder, however, when tried by the file, not in the least malleable, and of the specific gravity of 19.5. These he concluded to be an ore consisting entirely of iridium and osmium.

Iron. This metal is extremely diffused. It exists in the mineral kingdom in large quantities, and under numerous forms; it is a constituent principle of vegetable matter, and is obtained from the ashes of almost every plant; it exists in the blood, and other animal products; it is even an atmospheric or meteoric production, those stony masses which at different times, and in different countries, have fallen from the atmosphere, containing iron as their principal ingredient.

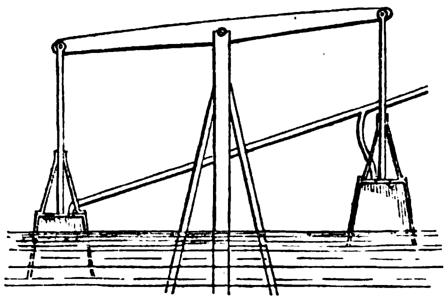
The ores from which iron is extracted are those in which it is mineralized by oxygen, of which there are many varieties, consisting of the oxide intermixed with argillaceous, calcareous, and silicious earths. It is principally from the argillaceous ore, or clay iron-stone, that iron is extracted in this country. After raising, the ores are picked, to separate, as far as possible, the considerable pieces of earthy or otherwise refractory matters, with which they may be associated. They are next submitted to a roasting, in large heaps, in the open air, to expel the sulphur and arsenic which they may contain, as well as to render them more friable and easy of further reduction to powder. The roasting is performed generally by bituminous coal. The result of the operation is, that it becomes full of fissures, friable, and loses altogether its vitreous lustre. It is now transferred to the crushing-mill, where it undergoes a further pulverization, after which it is transported to the smelting furnace, to be converted into iron. Here it passes through two distinct operations—1. the reduction of the oxide to the metallic state; 2. the separation of the earthy matters in the form of scoria. These processes consist in exposing the ore, ordinarily mixed with certain fluxes, to the action of carbon at an elevated temperature, in furnaces urged by bellows, hence called *blast-furnaces*, or sometimes *high-furnaces*. These furnaces vary in height from twelve to sixty feet, and have, externally, the shape of a four-sided pyramid, truncated at top, and terminating in a cylindrical chimney, whose internal diameter is from four to six feet. The interior body of these furnaces is usually in the circular form, except the laboratory at its bottom, where the liquid metal gathers. This, called sometimes the *crucible* or *hearth*, is a right-rectangular prism, oblong in the direction perpendicular to the blast orifices, or tuyeres of the bellows. The sides of the crucible are commonly made of a fine gritstone.

Above the crucible the boshes are placed, in the form of an inverted quadrangular pyramid, approaching to the prismastic shape; and above these stone boshes rises the conical body of the furnace, lined with fire-bricks, contracting as it ascends, like the narrow end of an egg, until it terminates in the chimney. The entire furnace is built in a very solid manner, and strengthened by bands and cross bars of iron. The bellows are usually cylindrical, and their pistons worked either by water or a steam-engine. The blast-holes, which are situated in the upper part of the crucible, are two in number, and frequently placed on opposite sides, but so angled that the currents of air do not impinge on each other. At the lower part of the crucible are openings for the discharge of the metal and scoria. These openings are kept stopped by accumulations of clay and sand upon the exterior when the furnace is in operation. The process of reduction commences by first gradually heating up the furnace, until it will bear to be filled entirely with fuel, after which, as the contents of the furnace begin to sink, alternate charges of ore mingled with flux, and of charcoal or coke, are added: the blast is let on, and the metal in the ore, parting with its oxygen, flows by degrees, and subsides to the bottom of the crucible, covered with a melted slag. The slag is occasionally allowed to flow off by removing the clay from some one of the apertures in the crucible; and when the bottom of the furnace becomes filled with the metal, which it ordinarily does after a space of nine or twelve hours, the iron itself is discharged by one of these openings, into a fosse of sand mingled with clay. As soon as the iron has flowed out, the aperture is closed again; and thus the furnace is kept in incessant activity.

The flux employed to assist the fusion of the ore, by vitrifying the earths associated in it with the oxide of iron, is limestone of the best quality. The iron which has run out from the blast-furnace is in the condition of cast-iron, or iron with a considerable portion of carbonaceous matter intermingled with its particles, and a small proportion of oxygen, from which causes it has a coarse grain, and is brittle. In converting it into bar-iron, it undergoes one or the other of the following processes, according as charcoal or coke is employed. In the former case, a furnace is made use of resembling a smith's hearth, with a sloping cavity sunk from ten to twelve inches below the blast-pipe. This cavity is filled with charcoal and scoria, and on the side opposite to the blast-pipe is laid a pig of cast-iron, well covered with hot fuel. The blast is then let in, and the pig of iron, being placed in the very focus of the heat, soon begins to melt, and, as it liquefies, runs down into the cavity below. Here, being out of the direct influence of the blast, it becomes solid, and is then taken out and replaced in its former position, the cavity being again filled with charcoal. It is thus fused a second time, and after that a third time, the whole of these three processes being usually effected in between three and four hours. As soon as the iron is become solid, it is taken out and very slightly hammered, to free it from the adhering scoria. It is then returned to the furnace, and is placed in a corner, out of the way of the blast, and well covered with charcoal, where it remains till, by further gradual cooling, it becomes sufficiently compact to bear the tilt, or trip-hammer, whose weight varies from 600 to 1200 lbs., and which is moved by water. Here it is well beaten, till the scoria are forced out, and is then divided into several pieces, which, by a repetition of heating and hammering, are drawn into bars, and in this state it is ready for sale.

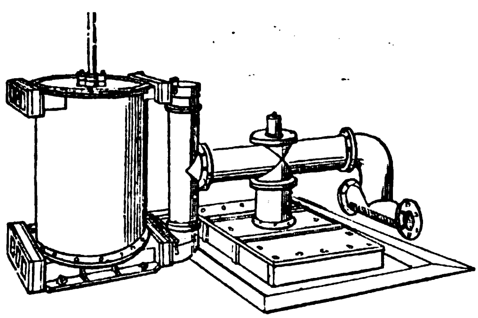
The stream of air employed in a blast-furnace is procured by various processes. The first and most

ancient is evidently that of a pair of bellows; but the friction of the leather is so great as to materially injure the working power. The apparatus represented beneath is in this respect a material improvement on the original arrangement.



A large beam is made to vibrate freely on the axis shown in the figure, and by its vibration the buckets are elevated and depressed. A flexible pipe moves with the buckets, and serves to carry the imprisoned and compressed air to the furnace. On elevating either of the buckets, the air is admitted by a valve opening inwards, which closes when it afterwards descends, and the air is thus forced along the pipe.

The piston blowing-machine is considerably employed, but requires a great deal more power than the one already described. It consists of a piston which nearly fits a case or cylinder, the latter being provided with pipes and valves above and beneath. The external appearance of the apparatus is shown in the figure. When the piston is raised it sucks air from a valve opening beneath, and, when it is depressed, air is drawn from above, and the blast proceeds from beneath.



A complete blast-machine put in operation by a band-wheel is shown at *fig.* 1, *Plate* I., Iron Manufacture.

A contrivance of great importance has lately been adopted in some of the mining districts, which is exceedingly simple, but much more effective than any which had gone before it. A series of vanes are attached to an axis, which is made to revolve with great rapidity in a box. A pipe passes from the outside of the box to the furnace, and as the vanes revolve the air is carried by its centrifugal force into the furnace, a new portion continually entering by a hole at the axis. A similar arrangement has been applied to an artificial blast for a common fireplace.

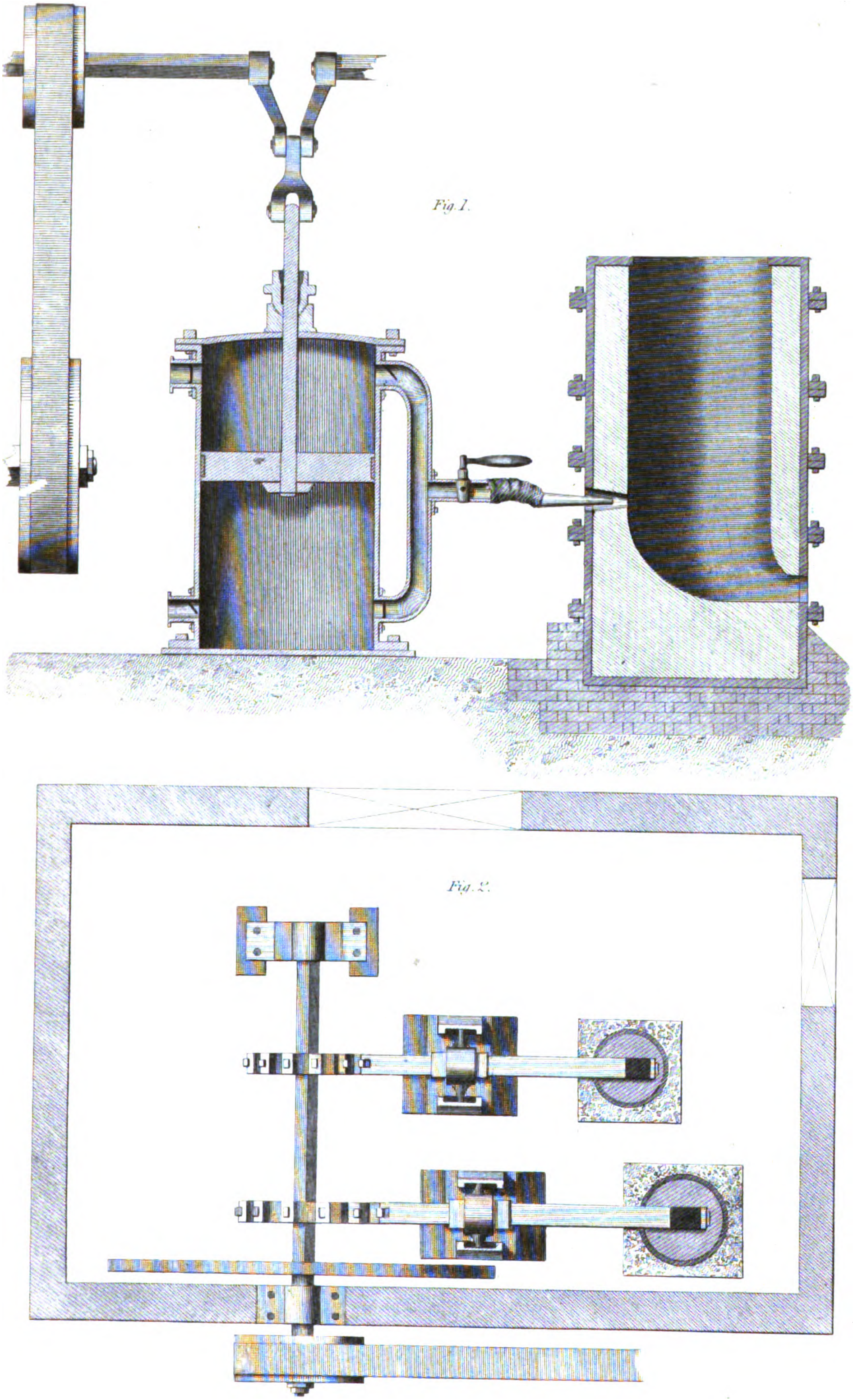
The proportion of pig-iron or cast-iron from a given quantity of ore is subject to considerable variation, from a difference in the metallic contents of different parcels of ore, and other circumstances; but the amount of bar-iron that a given weight of pig-iron is expected to yield is regulated very strictly, the workmen being expected to furnish four parts of the former for five of the latter, so that the loss does not exceed twenty per cent. The other process for the manufacture of bar-iron, and which is the one chiefly employed in this country, is executed in part in reverberatory furnaces, known by the name of *puddling-furnaces*. The operation commences with melting down the cast-iron in refinery furnaces, like the one above described. When the cast-iron is fully melted, a tap-hole is opened in the crucible, and the fine metal flows out, along with the slag, into a fosse covered with water mixed with clay, which forms a coating, to prevent the metal from sticking to the ground. The finer metal forms a plate ten feet long by three feet broad, and from two inches to two and a half thick. A great quantity of cold water is sprinkled on it, in order to make it brittle, and also to oxidize it slightly. The loss of weight in the iron, by this operation, is from twelve to seventeen per cent. It is then broken to pieces, and laid on the hearth of a reverberatory furnace, in successive portions, being heaped up towards its sides in piles which rise nearly to the roof. The middle space is left open, to give room for puddling the metal as it flows down in successive streams. When the whole is reduced, by the heat of the furnace, to a pasty state, the temperature is lowered, and a little water is sometimes thrown on the melted mass. The workman stirs about the semi-liquid metal with his puddle, during which it swells up, emits a considerable quantity of oxide of carbon, which burns with a blue flame, so that the mass appears to be on fire. The metal, as it refines, becomes less fusible, or, in the language of the workmen, it begins *to dry*. The puddling is continued till the whole charge is reduced to the state of an incoherent sand; then the temperature is gradually increased, so as to impart a red-white heat, when the particles begin to agglutinate, and the charge *works heavy*. The refining is now finished, and nothing remains but to form the metal into balls, and condense it under the rolling cylinders. The *balling-furnace* in which this melting takes place is shown in *Plate* II., *fig.* 3, Iron Manufacture. The iron is now to be passed through hard rollers. A pair of the best kind is shown at *fig.* 5, and an end view of the same at *fig.* 6. When the lump of iron has passed five or six times through the grooved rollers, it assumes an elliptic figure, and is called a *bloom*. Loose fragments of the ball, with the slag, fall down about the cylinder. The metal thus roughed down is called *mill bar-iron*. It is subjected to a second operation, which consists in welding several pieces together, whence it derives the valuable properties of ductility, uniformity, and cohesion. After welding laterally four pieces together, the mass is run through between a series of cylinders, as at first, and becomes English bar-iron.

Iron, for laminating into sheets, is treated in the refinery furnace with a charcoal, instead of a coke fire. The object of all these operations, as respects the treatment of cast-iron, is to convert it into tough iron, and thus to get rid of the slag, the oxygen, and the carbon, it contains. The first of these is separated in part by the long-continued fusion

IRON MANUFACTURE.

Fig. 1.

Fig. 2.



London, Published by William Orr, Paternoster Row, Aug.t 29, 1838.

Fig. 5.

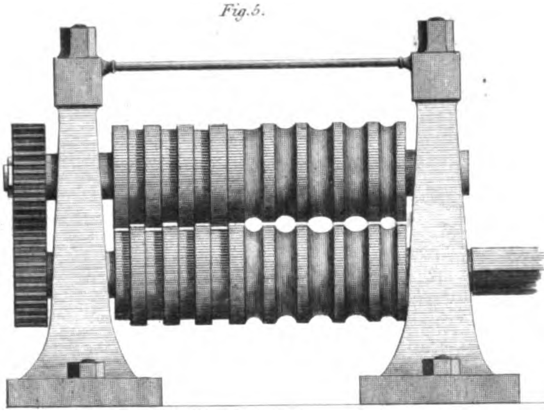
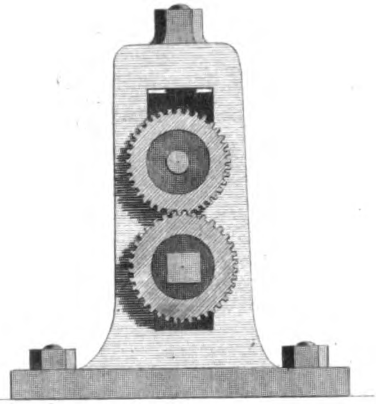


Fig. 6.



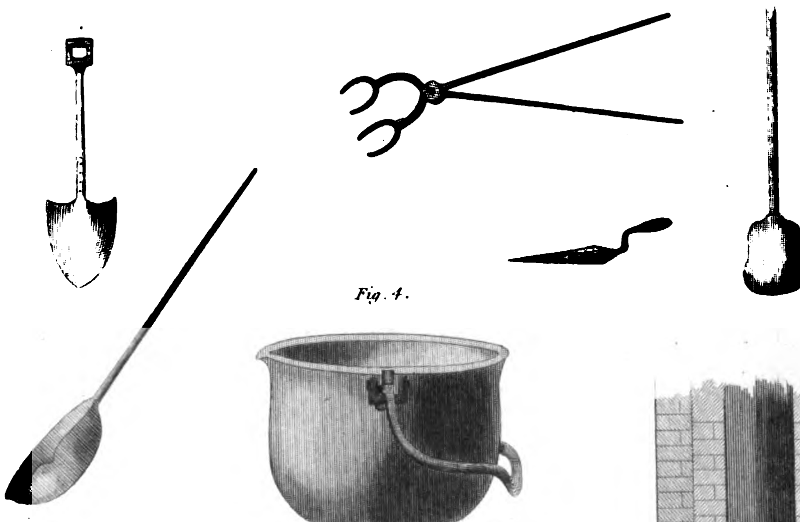
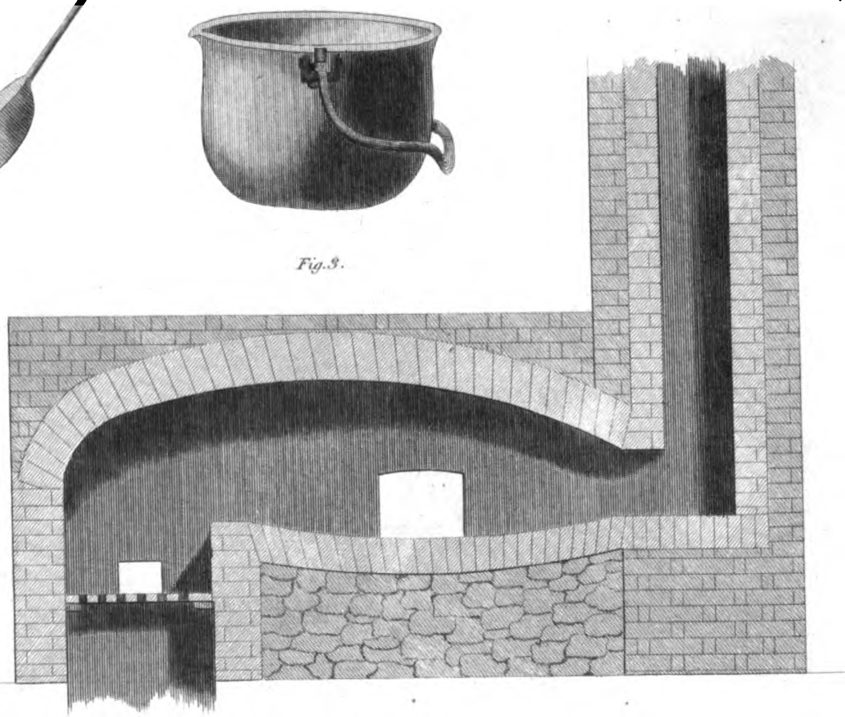


Fig. 4.

Fig. 3.



London, Published by William Orr Paternoster Row, Aug.t 29, 1833.

and the repose of the melted metal, in consequence of which the slag, being lighter than the bath, floats on its surface; but its more effectual removal is produced by the compression, in which process the earthy masses are forced through the pores of the bloom, or lump, as water exudes from a sponge. Among the different varieties of cast-iron, there are some which contain exactly the proportion of oxygen and carbon proper to form a gaseous combination. For the refinery of these, an elevated temperature, without access of air, is all that is necessary. These elements, re-acting upon one another, are dissipated in the aërial state; but there are likewise other varieties of cast-iron, in which the carbon is in excess. In this case, the free access of atmospherical air is requisite.

In order to understand how the carbon is abstracted from the interior of a mass of the liquefied metal by the oxygen of the atmosphere, which can only be in contact with the surface of the iron, we have merely to reflect upon the reverse process in the manufacture of steel, which consists in the introduction of carbon into iron. At first, an outer coat of iron, by being surrounded with charcoal powder, gets partially saturated with carbon. If, by pushing the cementing process, we wish to arrive at the complete saturation of that coat, we can succeed only by making a previous partition. The layer immediately beneath the first carries off from it a portion of its carbon; and it is not till itself is partly saturated that it suffers the outer coat to absorb its maximum dose of carbon, when it remains stationary; but an effect quite similar takes place with the second coat in reference to the third, that is, the one immediately within or beneath it. To apply these ideas to the refinery processes, the decarburation of the cast-iron is merely a restoration of the carbon to the surface, in tracing inversely the same progressive steps as had carried it into the interior during the smelting of the ore. Thus the oxygen of the air, fixing itself at first at the surface of the cast metal on the carbon which it finds there, burns it. Fresh charcoal, issuing from the interior, comes then to occupy the place of what had been dissipated, till, finally, the whole carbon is transferred from the centre to the surface, and is then converted into either carbonic acid gas, or oxide of carbon—an alternative which may fairly be allowed, since no direct experiment has hitherto proved what is the precise product of this combustion.

Malleable iron is frequently obtained directly from the ores by one fusion, when the metallic oxide is not too much contaminated with foreign substances. This mode of working, which is allowed to be vastly more economical than the one just described, on account of the saving both of time and combustibles, has for a long period been employed in Catalonia, in the Pyrennees, from which circumstance it is called the *method of the Catalonian forge*. Those ores best adapted to its treatment are the pure black oxide, red and brown oxide, and carbonate of iron, to extract the metal from which, it is sufficient to expose them to a high temperature in contact with charcoal or carbonaceous gases. The furnace employed is similar to the refiner's forge already described. The crucible is a kind of semicircular or oblong basin, eighteen inches in diameter, and eight or ten in depth, excavated in an area or small elevation of masonry, eight or ten feet long, by five or six broad, and covered in with a chimney. The tuyere stands five or six inches above the basin, and has a little inclination downwards, and the blast is given by a water blowing-machine. The first step consists in expelling the water combined with the oxide, as well as the sulphur and arsenic, when these contaminations are present. This is done, as usual, by roasting in the open air. The roasted ore is crushed to a tolerably fine powder, and thrown by the shovel-full, at intervals, upon the charcoal fire of the forge hearth, the sides and bottom of the basin being previously lined with two or three *brasques* (coats of pounded charcoal). It gradually softens and unites into lumps more or less coherent, which finally melt and accumulate in the bottom of the crucible or basin. A thin slag is occasionally let off from the upper surface of the melted iron in the basin, by means of holes which are opened and closed according to the discretion of the workmen. The melted iron preserves a pasty condition, owing to the heat communicated from above; and, when a mass of sufficient dimensions has accumulated, it is removed, put under the hammer, and forged at once. A tilt-hammer consisting of two beaters, worked by a wheel and axis furnished with teeth for raising the hammer, is shown at *fig.* 2, *Plate* I., IRON MANUFACTURE; and the remainder of the small tools employed in the foundry, at *fig.* 4, *Plate* II. A lump or bloom of malleable iron is thus produced in the space of three or four hours. The iron is generally soft, very malleable, and little steely. Four workmen are employed at one forge; and, by being relieved every six hours, they are enabled to make 86 cwt. of iron per week. In the Catalonian forges, 100 lbs. of iron are obtained from 300 lbs of ore (a mixture of sparry iron, or carbonate, and hematite) and 310 lbs. of charcoal, being a produce of 33 per cent.

The number of high furnaces in blast in England, Scotland, and Wales, at several periods, from 1740 up to 1827, have been collected from documents on which we consider every reliance may be placed:—

	Tons.
In 1740 the iron made amounted to	17,000
1788	68,000
1796	121,000
1806	250,000
1820	400,000
1827	690,000

In the year 1740, only fifty-nine furnaces were in blast; in 1778, they had increased to eighty-five; and in 1796, to 121; while the number of furnaces in blast in 1827 was 214.

An account of the number of works for blasting of iron in each mining district in Great Britain, with the average produce per week in each district, in the year 1825.

Mining Districts of	Number of Works.	Number of Furnaces. Total.	out of Blast.	in Blast.	Produce in Tons; per Week	Year.
1 South Wales	37	109	27	80	4,460	223,520
2 Staffordshire	54	108	27	80	3,503	171,735
3 Shropshire	23	49	13	36	1,723	86,320
4 Yorkshire	14	34	12	22	752	35,308
5 Scotland	9	25	8	17	645	29,200
6 Derbyshire	9	19	5	14	436	19,184
7 North Wales	9	14	6	8	303	13,100
8 All other parts of England	12	14	5	—	—	—
9 Ireland	1	2	—	2	60	3,000
Totals, 1825	168	374	103	261	11,883	581,367

There are four furnaces in South Wales, and nine in the other parts of England from which no return of produce has lately been obtained; consequently not included in the foregoing total of produce. The following is another account, derived from an authentic source, exhibiting a comparative view of the number of furnaces in and out of blast, in January 1826, and in April 1828.

	Mining Districts of	Number of Furnaces. Total	out of Blast	in Blast	Produce in Tons; per Week	Year.
January, 1826.	1 South Wales	109	27	82	4,430	230,412
	2 Staffordshire	108	27	81	3,503	182,156
	3 Shropshire	49	13	36	1,723	89,596
	4 Yorkshire	34	12	22	752	39,104
	5 Scotland	25	8	17	645	33,540
	6 Derbyshire	19	5	14	436	22,672
	7 North Wales	14	6	8	303	15,756
	Totals, January, 1826	359	99	260	11,793	613,236
April, 1828.	1 South Wales	100	11	89	5,376	279,512
	2 Staffordshire	120	25	95	4,220	219,492
	3 Shropshire	48	17	31	1,562	81,224
	4 Yorkshire	34	17	17	634	32,968
	5 Scotland	25	8	18	725	37,700
	6 Derbyshire	18	4	14	436	22,360
	7 North Wales	19	7	12	484	25,168
	8 Forest of Dean (Glo'stersh.)	2	1	1	50	2,600
	9 Duckinfield (Cheshire)	1	0	1	30	1,560
	Totals, April, 1828	367	90	278	13,512	702,624

According to the above statement, notwithstanding the progressive depreciation in the value of iron since 1825, seventeen additional furnaces were brought into blast in 1826-7, and the produce of some of the others considerably increased, so that in April 1828 the produce of 278 furnaces then in blast amounted to upwards of 700,000 tons of pig-iron; and this exclusive of four furnaces in South Wales, and nine in different parts of England, from which no return of produce had been obtained; so that the total produce probably amounted to not less than 735,000 tons. It has been estimated by some competent and high authorities that an average of 27 cwt. of pig-iron makes a ton of wrought-iron; while others estimate the average at 30 cwt. to the ton, and some even give a still greater average. Admitting the first estimate to be correct, 735,000 tons of pig is equal to 545,000 tons of wrought iron, out of which, in 1828, there was exported of wrought and unwrought iron and steel, to all parts of the world

	Tons
(Except Ireland)	100,265
And of hardwares and cutlery	12,488
Estimate of all kinds to Ireland	30,000
Do. of arms, machinery, and mill work	7,247
Making a total quantity exported of	150,000

Leaving for home consumption the enormous quantity of 395,000 tons; to which may be added about 50,000 tons of old iron, annually brought to re-manufacture, and the 12,000 tons of foreign. Admitting, however, that a ton of wrought-iron absorbs, on an average, 30cwt. of pig-iron, it will reduce the quantity of wrought from 545,000 to 490,000 tons, and the quantity left for home consumption from 395,000 to 340,000 tons.

Iron is oxidated and dissolved by the acids with facility; its saline compounds, when neutral, are in general soluble and crystallizable.

Sulphate of iron is a salt which has long been known under the name of *green vitriol*. It is economically prepared from the native sulphuret of iron, which, when calcined, and exposed for some time to air and humidity, absorbs oxygen, so that the sulphur is converted into sulphuric acid, and the iron is oxidated; the sulphate of iron, thus formed, is extracted by lixiviation and crystallization. It is obtained more pure by the direct solution of iron in diluted sulphuric acid, the acid enabling the iron to decompose the water by attracting its oxygen, and at the same time combining with the oxide. The solution is of a pale green colour, and if concentrated affords crystals of the same colour, in the form of rhomboidal prisms. This salt is soluble in six parts of cold water. Exposed to heat, it first liquefies; when the water of crystallization is dissipated, it forms a dry mass of a greenish colour; when urged by a strong heat, the greater part of its acid is expelled, partially decomposed, and a red oxide remains. Exposed to the air, it loses its transparency, and is covered with a yellowish crust; a change owing to the absorption of oxygen. This absorption takes place to a greater extent when the salt is in solution, and continues until the oxide passes to the maximum of oxidation. In this state it requires a larger quantity of acid for its saturation than the oxide in the green sulphate does; hence a portion of this more perfect oxide is precipitated, while the remaining quantity is retained in combination with the acid. The one of these salts is named the *green sulphate of iron*, the other the *red sulphate*. The latter is not crystallizable, but when its solution is evaporated it forms a mass of a yellowish-red colour. It is soluble in alcohol, and this affords a mode of separating it from the other. With re-agents, these salts afford different phenomena. The green sulphate, decomposed by the alkalies, gives precipitates of a green colour; the red sulphate affords precipitates of a yellow colour, approaching more or less to red; the former, with prussiate of potash, gives a white precipitate, the other, with the same test, a precipitate of a rich blue colour; the one is little altered by the infusion of galls, the other strikes immediately a deep purple colour.

From the strong tendency of iron to pass to a highly oxidated state, it is difficult to obtain the green sulphate perfectly pure, so as to exhibit these phenomena. The solution of iron is usually in an intermediate state of oxidation: and though Proust and some other chemists have supposed that there are only two sulphates of iron of determinate composition, one having for its base the metal at the *minimum*, the other at the *maximum* of oxidation, and that any apparent intermediate compound is merely a mixture of these, crystals of numerous shades of colour can be obtained, denoting a series of these compounds in different degrees of oxidation. The different precipitates which the compounds form with the different re-agents, the prussiate of potash, and infusion of galls, have been supposed to depend on the peculiar properties of the oxides, which are their bases: but they appear also to arise in part from the different forces of affinity with which the oxide is retained in combination with the sulphuric acid, the force being greater exerted towards the metal at a low than at a high degree of oxidation, so that the salt in the former state does not so easily form a precipitate with these re-agents. Hence, if the affinity be weakened by causes which do not change the state of oxidation, as by mere dilution with water, or by the addition of

an alkali in small proportion, the precipitation is produced by their action on the salt in even the least oxidated state.

Sulphate of iron is applied to numerous uses in the arts, more particularly in dyeing, as forming, with vegetable astringents, the basis of black dyes, and, with other colouring substances, different shades of colour. Its combination with these astringents is the basis of writing-ink.

Sulphurous acid dissolves iron, being partly decomposed, so that the combination is a sulphuretted sulphite of iron, "or rather a hypo-sulphite of iron." The pure sulphite is obtained by the direct combination of the acid with oxide of iron; it is soluble in water, but not in alcohol, and is not coloured by infusion of galls. "The hypo-sulphite, it has been ascertained, is formed also when carbonate of iron is dissolved in sulphurous acid, and the solution afterwards boiled with sulphur. If acid be added to a solution of the hypo-sulphite, sulphurous acid will be evolved, and sulphur deposited. By evaporation, the hypo-sulphite is obtained in crystals."

Nitric acid is decomposed by iron with rapidity, and the metal passes to the highest state of oxidation. When the acid is diluted, the action is more moderate, and a more perfect solution is obtained, which, however, cannot be evaporated so as to afford the nitrate crystallized, the heat that is required causing a further decomposition of the acid, and the precipitation of a sub-nitrate of iron. A similar change is produced in the solution from exposure to the air, oxygen being absorbed.

Muriatic acid dissolves iron with facility, the iron receiving oxygen from the water, and the solution being therefore attended with a disengagement of hydrogen gas. The liquor is of a pale green colour, and by evaporation affords crystals of the same colour. If oxide or rust of iron is dissolved in muriatic acid, a solution is obtained of a yellow colour, which does not crystallize on evaporation, but affords a soft deliquescent mass. In one of these salts the iron is in a low, in the other in a high state of oxidation, and they differ in their chemical properties; the former, the green muriate, is insoluble in alcohol, is little altered in its colour by infusion of galls, and, when decomposed by the alkalies, gives a green precipitate; the latter, the red muriate, is soluble in alcohol, gives a deep purple colour with galls and a blue with prussiate of potash, and affords a yellow precipitate when decomposed by the alkalies. The green is converted into the red muriate by exposure to the air, passing through various intermediate states of oxidation by absorption of oxygen. The solution of the green muriate, as well as of the green sulphate of iron, absorbs nitric oxide gas, a property the application of which to eudiometry has been already adverted to.

In oxymuriatic gas, iron wire, when heated, suffers combustion, and a product is obtained of a yellowish colour, with considerable lustre, volatile and soluble in water. With a smaller proportion of the acid, a compound is obtained, which is fusible, but not volatile. The one appears to be the red, the other the green muriate in a dry and concentrated state.

Iron is acted on by water strongly impregnated with carbonic acid, and a portion of it is dissolved. The common rust of iron contains a portion of this acid; and a carbonate is formed by decomposing sulphate of iron by carbonate of potash or soda; it is precipitated of a greenish colour, but in drying becomes brown from absorption of oxygen from the air. In the natural chalybeate waters, the iron is usually held dissolved by carbonic acid.

Phosphoric acid acts weakly on iron; but the phosphate may be formed by adding phosphate of soda to a solution of sulphate of iron; it is of a white colour, insoluble in water, and fuses into a brilliant globule by intense heat. The borate, formed by a similar process, is insoluble. The fluate is soluble, does not crystallize, but by evaporation forms a gelatinous mass. Prussic acid has a powerful affinity to oxide of iron: it forms with the red oxide the pigment, of a rich blue colour, known by the name of *Prussian blue;* and from the deepness of the colour of this combination, and the strength of affinity which the acid exerts, it affords one of the most delicate tests of iron. Gallic acid produces with the salts of iron, in the higher degrees of oxidation, a deep violet tinge, and in the state in which it is combined with tannin in the infusions of vegetable astringents, particularly of galls, is a test still more delicate and more accurate. Succinic acid forms with oxide of iron an insoluble compound, and from this property has been employed to abstract iron from other combinations, or in delicate analyses to ascertain the quantity of iron. Benzoic acid has a similar effect, and, being less expensive than succinic acid, has been employed under the form of benzoate of ammonia.

The alkalies scarcely act on iron or its oxides; in decomposing its salts, they in some cases form, when added in excess, soluble ternary compounds. The earths when melted with oxide of iron form coloured enamels.

Iron appears to exert a strong attraction for carbon. When melted from its ores in contact with the fuel, a portion of carbonaceous matter combines with it, and this, with oxygen and other ingredients, forms cast-iron. The combination of iron with carbon alone constitutes *steel,* one of the most useful forms of this valuable metal.

The usual process for forming steel is that named *cementation,* in which bars of malleable iron are imbedded in layers of charcoal-powder in a close furnace, through which flues are carried to distribute the heat: a strong fire is applied for six or eight days; the progress of the cementation is known by withdrawing a bar from the furnace: if this is sufficiently changed, the fire is extinguished, and the metal is left to cool for six or eight days. This forms *blistered-steel;* it is rendered more perfect by subjecting it to the operation of the forge-hammer, as in forging iron; or by welding it; or it is fused with the addition of a little charcoal, and cast into small bars, forming what is named *cast-steel.* These operations are performed on malleable iron; but some kinds of cast-iron, particularly the gray crude iron, can be converted into steel of an inferior quality by a similar process. Steel is also formed by fusing forged iron with charcoal.

In this operation, an increase of weight from $\frac{1}{150}$th to $\frac{1}{140}$th is gained. The more carbon is introduced, the more brittle is the steel. Bergman first clearly showed the presence of this carbonaceous matter, by ascertaining by experiment that less hydrogen is disengaged during the solution of steel in diluted sulphuric acid than during the solution of iron in the same acid; and that, during the solution of the steel, carbon is precipitated in the form of a black shining

powder, similar to plumbago. Guyton has observed that it is probably pure carbon, not charcoal, that is present in steel; and to this its great hardness may be ascribed. This has been confirmed by the experiment of converting iron into steel, by exposing it to heat with diamond. Bergman further found that some specimens of steel contain manganese and silicious earth; and Vauquelin has likewise discovered the existence of this earth, or perhaps rather its metallic base, and of phosphorus, in several kinds of steel which he analysed.

Steel is of a gray colour; when heated it assumes various brilliant colours on its surface from oxidation; its fracture is granular and brilliant, and it is susceptible of a high polish. It is more fusible than iron. It is ductile and malleable, and, when hammered, its ductility and its elasticity are increased. The property by which it is eminently distinguished is that of acquiring a great degree of hardness by being immersed in cold water when previously heated, the hardness being greater as the steel has been hotter and the water colder; it at the same time becomes more brittle and elastic, effects which evidently arise from the irregular aggregation produced by the sudden cooling. Steel, thus hardened, may have its softness and ductility restored, by again heating it, and allowing it to cool slowly. This is what is termed *tempering* of it, the requisite degree of *temper* being given by heating the metal more or less, previously to the slow cooling. The harder steel is, the more elastic it becomes, and at the same time the more brittle, and hence, for different purposes, different degrees of this quality are required.

Steel possesses a degree of hardness superior to that of any other metal; it is also possessed of the highest elasticity; and from these properties it acquires its high value.

The mineral substance known by the name of *plumbago*, or *graphite*, is a compound of iron and carbon. The proportion of iron is variable, but in general does not exceed from 3.5 to 10 in 100 parts. By exposure to a continued red heat, the carbonaceous matter is slowly consumed, being converted into carbonic acid, and oxide of iron remains. It suffers a similar change by deflagration with charcoal. It is scarcely acted on by the acids. From its softness and lubricity, plumbago is used to lessen the friction of machinery; it is added to some kinds of earthenware, to communicate a degree of tenacity, whence the composition is not so liable to crack on exposure to heat. It is rubbed on the surface of iron to prevent rusting; and it forms the best kind of crayons.

Iron has a strong attraction for sulphur, and combines with it with facility by fusion, the combination being attended with the evolution of heat and light. They also exist combined in nature, the mineral named *pyrites* being a combination of this kind. The proportions of the ingredients in the native sulphurets are usually different from those in the artificial sulphuret; in the former they are about fifty-three of sulphur and forty-seven of iron; in the latter the proportion of sulphur does not exceed thirty-seven. There exists, however, a native sulphuret named *magnetic pyrites*, similar in composition to the artificial sulphuret; and, on the other hand, the artificial sulphuret may be combined by fusion with an additional proportion of sulphur. When the proportion does not exceed thirty-seven of sulphur in 100 parts of the compound, the magnetic property remains; but, when it is so high as fifty-three, it is destroyed. These compounds are of a gray or yellow colour, frequently variegated, with a degree of lustre, the colour approaching more to yellow, and the lustre being more perfect, as the proportion of sulphur is large. They are of a crystalline texture, brittle, and fusible, and are partially decomposed by heat. The compound in which the iron predominates, when moistened and exposed to the air, absorbs oxygen, and is gradually converted into sulphate of iron. A mixture of iron-filings and sulphur moistened acts on atmospheric air in a similar manner, and suffers the same change. The alkaline sulphurets combine with iron by fusion, and also by boiling with water. Sulphuretted hydrogen, and the hydro-sulphurets, form precipitates from the salts of iron.

With phosphorus iron forms a compound which is white, brittle, and of a granular fracture. A compound of this kind, obtained from cast-iron, was once regarded as a peculiar metal, and named *siderite*. It has been considered as the cause of the cold short property of iron.

Iron combines with a number of the metals, but few of its alloys are applied to use. That with gold is hard, ductile, and malleable, but of a dull gray colour. With silver it combines imperfectly. With platina the combination is not easily effected, from the infusibility of both metals. It does not easily amalgamate with quicksilver; the combination can be produced only by indirect methods, and is imperfect. The alloy with copper is brittle, and of a gray colour. The principal alloy of any use is that with tin, this forming what is named *tinned iron*.

Iron is perhaps the most useful of the metals, possessing in its pure form the highest degree of tenacity, ductility, elasticity, and hardness, whence it is applied to all purposes where strength is required; and, though infusible, it is capable by the operation of welding of being easily fashioned and worked. Cast-iron, being fusible, can be adapted to other purposes, and derives value from its hardness, and from being less liable than forged iron to be acted on by the air. And the elasticity and hardness of steel adapt it to numerous uses for which other metals would afford very imperfect substitutes.

IRON-WOOD. This name is given to a small tree, having the foliage of a birch, and the fruit somewhat resembling that of the hop. It is remarkable for the hardness and heaviness of the wood, which, however, has not hitherto been applied to any very important uses, partly on account of its small size. The trunk usually does not exceed six inches in diameter; but the excellent qualities of the wood may, at some future day, be better appreciated. The term *hop-hornbeam*, derived from the form of the fruit, is frequently applied to the species of *ostrya*.

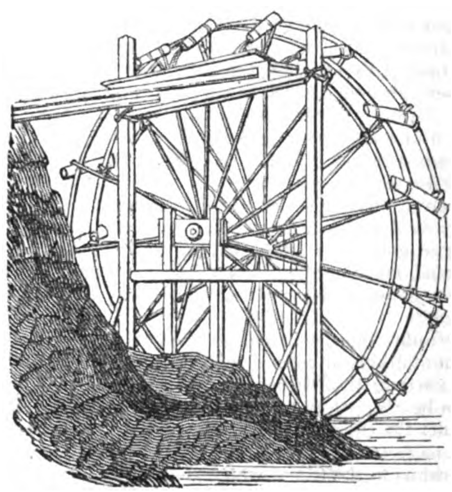
IRRATIONAL QUANTITIES are those which cannot be measured by unity or parts of unity; for example, the square root of 2, 1.4124 .... which, by continued approximation, can be obtained more and more exactly, without end, in parts of unity, but can never be exactly determined. The relation of two quantities is also called *irrational* when one cannot be exactly measured by the whole and parts of the other. The circumference and diameter of a circle stand in such an *irrational* relation to each other, because we can only find by approximation how many times the latter is contained in the former.

IRRIGATION. The fertilizing of land by artificial

streams is a subject of the greatest importance to the agriculturist. To make the matter intelligible to the reader, it will be necessary for us to point out the various processes for irrigating land which are resorted to in different parts of the globe. We may commence with the East.

In Hindostan the operation of conveying water to and from the fields is one of the most expensive and troublesome in their agricultural system, particularly in the higher districts. In the Monghere districts of Bengal, a deep well is dug in the highest part of the field, which, being ploughed, is divided into little square plots, resembling the chequers of a chess-board. Each square is surrounded with a border, four inches high, capable of containing water; while, between the chequers thus constructed, small dykes are formed for conveying a rivulet over the whole field. As soon as the water has stood a sufficient time in one square for it to imbibe moisture, it is let off into the next by opening a small outlet through the dyke. Thus one square after another is irrigated, till the whole field is gone over. The water is raised in leathern bags by two bullocks, yoked to a rope; the cattle retiring from the well, and returning to its mouth, according as the bag is meant to be raised or to descend. The rope is kept perpendicular in the pit by a pulley, over which it runs; and, from the mouth of the well thus placed, the rivulets are formed. In Patna the buckets are raised by large bamboo levers, as buckets are in this country.

Dr. Davy gives an interesting account of the prevalence of this practice at Ceylon. The cultivation in the interior of that country, he says, is of two kinds, the dry and the wet. The former consists in cutting down and grubbing up the wood on the sides of hills, where particular varieties of rice and Indian corn are afterwards sown: the latter, and by far the most general mode, is carried on wherever water can be obtained for irrigation. "Most of the operations in the cultivation of *paddy*," he states, "are connected with or have some relation to the element on which its success depends. The farmer commences with repairing the banks of the paddy-field. He then admits water in sufficient quantity to be an inch or two deep over the whole surface. After the ground has been well macerated and softened, he ploughs it, still under water. After further maceration, it is ploughed again, or merely trampled over by buffaloes, till reduced to the state of mud. Its surface is now levelled and smoothed; the water is drawn off; and the paddy, having been previously steeped in water till it has begun to germinate, is sown with the hand, and is scattered as equally as possible over the moist surface of mud. When the seed has taken root, and before the mud has had time to dry, the openings through which the water was drawn off are closed, and the field is again inundated. When the paddy is two or three inches high, it is weeded; and, where the seed has failed, the vacant spots are planted from those parts which are too thick and require thinning. The irrigation is continued till the paddy is nearly full-grown and about to ripen, when openings are made in the banks and the field is drained. As soon as ripe, the paddy is cut with reaping-hooks, and immediately carried to the threshing-floor, where the grain is trampled out by buffaloes. From the moment the seed is sown, till the period of harvest, the paddy-field, like the chenas, requires constant nightly watching to protect it from the depredations of its wild enemies. In the low country, where the cultivation of paddy is in a great measure dependent on the rainy season, and on artificial reservoirs for a further supply of water, only one crop is procured annually; but amongst the mountains, in situations where perpetual irrigation is at command, the seasons are less concerned, the farmer can sow when he pleases, and from good ground annually obtain two, and I have heard even three crops. The hilly and mountainous districts, in consequence of being well supplied with water, are thus particularly favourable for the cultivation of this important grain: and it is a most fortunate circumstance that they are so; otherwise the coolest, most salubrious, and most beautiful parts of the interior would, instead of being cultivated to a certain extent, be quite neglected and deserted. In the low country the paddy-fields are generally of a large size, and apparently quite flat; and every crop being in the same state of vegetation, or nearly so, the whole exhibits very little variety of surface. Amongst the mountains it is quite different: paddy-fields there are a succession of terraces, or flights of steps; and in each field the crop may be in different stages of growth,—in some just vegetating, in others full-grown, ripening, or ripe; there, at the same time, you may see the labourers at all their different operations,—banking, ploughing, sowing, weeding, reaping, and treading out the grain. In the low lands the labour and skill required to cultivate paddy are less than are necessary in the high lands. In cutting terraces in the sides of hills, the perseverance and industry of the mountaineer are often in a striking manner displayed. Many of his beds are actually walled up, and many of them are not four feet wide, and, though generally long, occasionally they are so short, from the nature of the ground, as well as narrow, that one would not suppose they were worth the labour of keeping in repair, and much less of making. In bringing water to his fields, and insuring them a constant supply, the judgment and skill of the cultivator are most exercised. Sometimes it is conducted two or three miles along the side of a hill, and occasionally it is even carried from one side of a mountain to another by means of wooden pipes."



The process for irrigating land with wheels em-

ployed in China is curious, and might be adopted with advantage in many situations in this country. The wheel must be of considerable size, and a running stream is of course necessary to give motion to it. At the extremity of the radial spokes are placed a number of earthen pots. These pots fill as they pass through the water, and then discharge their fluid contents into the series of troughs at the top, whence it is conveyed to the land to be fertilized.

"In *surface* irrigation," says Mr. Loudon, "the water is conveyed in a system of open channels, which require to be most numerous in such grounds as are under drilled annual crops, and least so in such as are sown in breadths, beds, or ridges, under perennial crops. This mode of watering has existed from time immemorial. The children of Israel are represented as sowing their seed and watering it with their feet; that is, as Calmet explains it, raising the water from the Nile by a machine worked by the feet, from which it was conducted in such channels as we have been describing. It is general in the south of France and Italy; but less required in Britain.

"Irrigation with a view to conveying additions to the soil (or for manuring it in fact) has long been practised, and is an evident imitation of the overflowing of alluvial lands, whether in meadow or arable. In the former case it is called irrigation or flooding, and in the latter warping. Warping is used chiefly as a mode of enriching the soil by an increase of the alluvial depositions, or warp, of rivers, during winter, where the surface is not under crop, as is common on the banks of the Ouse.

"*Subterraneous* irrigation appears to have been first practised in Lombardy, and first treated of by Professor Thouin. It consists in saturating a soil with water from below, instead of from the surface, and is effected by surrounding a piece of ground by an open drain or main, and intersecting it by covered drains communicating with this main. If the field is on a level, as in most cases where the practice is adopted in Lombardy, all that is necessary is to fill the main and keep it full till the lands have been sufficiently soaked. But, if it lie on a slope, then the lower ends of the drains must be closely stopped, and the water admitted only into the main on the upper side: this main must be kept full till the land is soaked, when the mouths of the lower drains may be opened to carry off the superfluous water. The practice is applicable either to pasture or arable lands. In Britain, subterraneous irrigation has been applied in a very simple manner to drain bogs and morasses, and to fen lands. All that is necessary is to build a sluice in the lower part of the main drain, where it quits the drained grounds, and in dry weather to shut down this sluice, so as to dam up the water and throw it back into all the minor open drains, and also the covered drains. This plan has been adopted with success in several parts of England."

"Subterraneous irrigation may be effected by a system of drains or covered gutters in the subsoil, which proceeding from a main conduit, or other supply, can be charged with water at pleasure. For grounds under the culture of annual plants, this mode would be more convenient, and for all others more economical as to the use of water, than surface irrigation. Where the under stratum is gravelly, and rests on a retentive stratum, this mode of watering may take place without drains, as it may also on perfectly flat lands, by filling to the brim, and keeping full for several days, surrounding trenches; but the beds or fields between the trenches must not be of great extent. This practice is used in Lombardy, on the alluvial lands near the embouchures of the Po. In Lincolnshire the same mode is practised by shutting up the flood-gates of the mouths of the great drains in the dry seasons, and thus damming up the water through all the ramifications of the drainage from the sea to their source. This was first suggested by Mr. Rennie and Sir Joseph Banks, after the drainage round Boston, completed about 1810. A similar plan, on a smaller scale, had been practised in Scotland, where mosses had been drained and cultivated on the surface, but where, in summer, vegetation failed from a deficiency of moisture. It was first adopted by James Smith on a farm in Ayrshire, and has subsequently been brought into notice by J. Johnstone, the first delineator and professor of Elkinton's system of draining.

"In general, in nature, the operation of water," says Sir H. Davy, "is to bring earthy substances into an extreme state of division. But, in the artificial watering of meadows, the beneficial effects depend upon many different causes, some chemical, some mechanical. Water is absolutely essential to vegetation; and when land has been covered by water in the winter, or in the beginning of spring, the moisture that has penetrated deep into the soil, and even the subsoil, becomes a source of nourishment to the roots of the plants in the summer, and prevents those bad effects that often happen in lands in their natural state, from a long continuance of dry weather. When the water used in irrigation has flowed over a calcareous country, it is generally found impregnated with carbonate of lime; and in this state it tends, in many instances, to emeliorate the soil. Common river-water also generally contains a certain portion of organizable matter, which is much greater after rains than at other times; or which exists in the largest quantity when the stream rises in a cultivated country. Even in cases when the water used for flooding is pure, and free from animal or vegetable substances, it acts by causing a more equable diffusion of nutritive matter existing in the land; and in very cold seasons it preserves the tender roots and leaves of the grass from being affected by frost. Water is of greater specific gravity at 42° Fahrenheit than at 32°, the freezing point; and hence, in a meadow irrigated in winter, the water immediately in contact with the grass is rarely below 40°, a degree of temperature not at all prejudicial to the living organs of plants. In 1804, in the month of March, the temperature in a water meadow near Hungerford was examined by a very delicate thermometer. The temperature of the air at seven in the morning was 29°. The water was frozen above the grass. The temperature of the soil below water, in which the roots of the grass were fixed, was 43°. Water may also operate usefully in warm seasons by moderating temperature, and thus retarding the over-rapid progress of vegetation. The consequence of this retardation will be a greater magnitude and improved texture of the grosser parts of plants, a more perfect and ample developement of their finer parts, and, above all, an increase in the size of their fruits and seeds. We apprehend this to be one of the principal uses of the flooding of rice-grounds in the east; for it is ascertained that the rice plant will perfect its seeds in Europe, and even in this country,

without any water beyond what is furnished by the weather, and the natural moisture of a well-constituted soil."

IRRITABILITY; the contractility of muscular fibres, or a property peculiar to muscles, by which they contract, upon the application of certain *stimuli*, without a consciousness of action. This power may be seen in the tremulous contraction of muscles when lacerated, or when entirely separated from the body in operations. Even when the body is dead, to all appearance, and the nervous power is gone, this contractile power remains till the organization yields, and begins to be dissolved. It is by this inherent power that a cut muscle contracts, and leaves a gap, that a cut artery shrinks, and grows stiff after death. This irritability of muscles is so far independent of nerves, and so little connected with feeling, which is the province of the nerves, that, upon stimulating any muscle by touching it with caustic, or irritating it with a sharp point, or driving the electric spark through it, or exciting with the metallic conductors, as those of silver or zinc, the muscle instantly contracts, although the nerve of that muscle be tied; although the nerve be cut so as to separate the muscle entirely from all connection with the system; although the muscle be separated from the body; although the creature, upon which the experiment is performed, may have lost all sense of feeling and have been long apparently dead. Thus a muscle, cut from the limb, trembles and palpitates a long time after; the heart, separated from the body, contracts when irritated: the bowels, when torn from the body, continue their peristaltic motion, so as to roll upon the table, ceasing to answer to *stimuli* only when they become stiff and cold. Even in vegetables, as in the sensitive plant, this contractile power lives. Thence comes the distinction between the *irritability* of muscles and the *sensibility* of nerves; for the irritability of muscles survives the animal, as when it is active after death; it survives the life of the part, or the feelings of the whole system, as in universal palsy, where the vital motions continue entire and perfect, and where the muscles, though not obedient to the will, are subject to irregular and violent actions; and it survives the connection with the rest of the system, as when animals very tenacious of life are cut into parts; but *sensibility*, the property of the nerves, gives the various modifications of sense, as vision, hearing, and the rest; gives also the general sense of pleasure or pain, and makes the system, according to its various conditions, feel vigorous and healthy, or weary and low.

The eye feels and the skin feels; but their appointed *stimuli* produce no motions in these parts: they are sensible, but not irritable. The heart, the intestines, the urinary bladder, and all the muscles of voluntary motion, answer to *stimuli* with a quick and forcible contraction; and yet they hardly feel the *stimuli* by which these contractions are produced, or, at least, they do not convey that feeling to the brain. There is no consciousness of present stimulus in those parts which are called into action by the impulse of the nerves, and at the command of the will; so that muscular parts have all the irritability of the system, with but little feeling, and that little owing to the nerves which enter into their substance; while nerves have all the sensibility of the system, but no motion. After every action in an irritable part, a state of rest, or cessation from motion, must take place before the irritable part can be again incited to action. If, by an act of volition, we throw any of our muscles into action, that action can be continued only for a certain space of time. The muscle becomes relaxed, notwithstanding all our endeavours to the contrary, and remains a certain time in that relaxed state before it can be again thrown into action. Each irritable part has *stimuli* which are peculiar to it, and which are intended to support its natural action: thus blood is the stimulus proper to the heart and arteries; but if, by any accident, it gets into the stomach, it produces sickness or vomiting. The urine does not irritate the tender fabric of the kidneys, ureters, or bladder, except in such a degree as to preserve their healthy action; but, if it be effused into the cellular membrane, it brings on such a violent action of the vessels of these parts as to produce gangrene. Such *stimuli* are called *habitual stimuli* of parts.

Each irritable part differs from the rest in regard to the quantity of irritability which it possesses. This law explains to us the reason of the great diversity which we observe in the action of various irritable parts; thus the muscles of voluntary motion can remain a long time in a state of action, and, if it be continued as long as possible, another considerable portion of time is required before they regain the irritability they lost; but the heart and arteries have a more short and sudden action, and their state of rest is equally so. The circular muscles of the intestines have also a quick action and short rest. The action of every stimulus is in an inverse ratio to the frequency of its application. A small quantity of spirits, taken into the stomach, increases the action of its muscular coat, and also of its various vessels, so that digestion is thereby facilitated. If the same quantity, however, be taken frequently, it loses its effect. In order to produce the same effect as at first, a larger quantity is necessary; and hence the origin of dram drinking. The more the irritability of a part is accumulated, the more that part is disposed to be acted upon. It is on this account that the activity of all animals, while in perfect health, is much livelier in the morning than at any other part of the day; for, during the night, the irritability of the whole frame, and especially that of the muscles destined for labour, viz. the muscles for voluntary action, is re-accumulated. The same law explains why digestion goes on more rapidly the first hour after food is swallowed than at any other time; and it also accounts for the great danger that accrues to a famished person upon first taking in food.

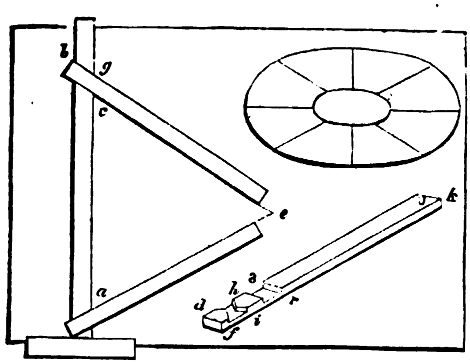
In German philosophy, *irritability, sensibility,* and *reproductivity* constitute the whole of organic life. Since the time of Schelling, *irritability* is much considered in the mental philosophy of that country. The French, treating the subject merely with reference to physiology, generally use, at present, the word *contractility* instead of *irritability*.

ISINGLASS. This substance is almost wholly gela tine, 100 grains of good dry isinglass containing rather more than ninety-eight of matter soluble in water. It is brought principally from Russia. The belluga yields the greatest quantity, being the largest and most plentiful fish in the rivers of Muscovy; but the sounds of all fresh-water fish yield more or less fine isinglass, particularly the small sorts, found in prodigious quantities in the Caspian Sea, and several hundred miles beyond Astracan, in the Wolga, Yaik,

Don, and even as far as Siberia. It is the basis of the Russian glue, which is preferred to all other kinds for strength. Isinglass receives its different shapes in the following manner. The parts of which it is composed, particularly the sounds, are taken from the fish while sweet and fresh, slit open, washed from their slimy covering, divested of a very thin membrane which envelopes the sound, and then exposed to stiffen a little in the air. In this state, they are formed into rolls about the thickness of a finger, and in length according to the intended size of the staple; a thin membrane is generally selected for the centre of the roll, round which the rest are folded alternately, and about half an inch of each extremity of the roll is turned inwards. Isinglass is best made in the summer, as frost gives it a disagreeable colour, deprives it of its weight, and impairs its gelatinous principles. Isinglass boiled in milk forms a mild, nutritious jelly, and is thus sometimes employed medicinally. This, when flavoured by the art of the cook, is the *blanc-manger* of our tables. A solution of isinglass in water, with a very small proportion of some balsam, spread on black silk, is the court-plaster of the shops. Isinglass is also used in fining liquors of the fermented kind, and in making mock-pearls, stiffening linens, silks, gauzes, &c. With brandy it forms a cement for broken porcelain and glass. It is also used to stick together the parts of some musical instruments.

Isometrical Perspective. A new process for drawing in perspective, under this title, has been introduced by Professor Farish of Cambridge. It is preferable to the common perspective on many accounts, especially for the exhibition of machinery. It is both easy and simple in its principles. It is effected by the help of a common drawing-table, and two rulers; so that there is no difficulty in giving an almost perfectly correct representation of any object adapted to this perspective, to which the artist has access, if he has a very simple knowledge of its principles and a little practice.

It is unnecessary to describe the accompanying drawing-table any further than by observing that it ought to be so contrived as to keep the paper steady on which the drawing is to be made.



There should be a ruler in the form of the letter T, to slide on one side of the drawing table. The ruler should be kept, by small prominences on the under side, from being in immediate contact with the paper, to prevent its blotting the fresh drawn lines as it slides over them; and a second ruler, by means of a groove near one end on its under side, should be made to slide on the first. The groove should be wider than the breadth of the first ruler, and so fitted that the second may at pleasure be put into either of the two positions represented in the engraving, so as to contain with the former ruler, in either position, an angle of sixty degrees. The groove should be of such a size that, when its shoulder *a* is in contact with and resting against the edges of the first ruler, the edges of the second ruler should coincide with *e*. When the shoulders *b c* rest against the edges of the first ruler, the edge of the second should lie along *a e*, the other side of the equilateral triangle. The second ruler should have a little foot at *k*, for the same purpose as the prominences on the first ruler; and both of them should have their edges divided into inches and tenths, or eighths of tenths.

It would be convenient if the second ruler had also another groove, *r s*, so formed that when the shoulders *r* and *s* are in contact with the edges of the first ruler the second should be at right angles to it. For representing circles in their proper positions, Professor Farish made use of the inner edge of rims cut out from cards into isometrical ellipses, as represented in the figure; of these he had a series of different sizes, corresponding to his wheels.

The Professor states that "by this apparatus we may represent the straight lines which lie in the three principal directions, all on the same scale. The right angles contained by such lines are always represented either by angles of sixty degrees, or the supplement of sixty degrees: and this, though it might look like an objection, will be understood on the first sight of a drawing on these principles by any person who has ever looked at a picture; for he cannot for a moment have a doubt that the angle represented is a right angle, on inspection."

And we may observe further that an angle of sixty degrees is the easiest to draw of any angle in nature. It may instantly be found by any person who has a pair of compasses, and understands the first proposition in Euclid. The representation, also, of circles and wheels, and of the manner in which they act on one another, is very simple and intelligible. The principles of this perspective, which, from the peculiar circumstance of its exhibiting the lines in the three principal dimensions on the same scale, which the Professor denominates "isometrical," will be understood from the following detail:—Suppose a cube to be the object represented, the eye placed in the diagonal of the cube produced, the paper on which the drawing is to be made to be perpendicular to that diagonal, between the eye and the object, at a due proportional distance from each, according to the scale required. Let the distance of the eye, and consequently that of the paper, be indefinitely increased, so that the size of the object may be inconsiderable in respect of it. It is manifest that all the lines drawn from any points of the object to the eye may be considered as perpendicular to the picture, which becomes, therefore, a species of orthographic projection; and the projection will have for its outline an equi-angular and equilateral hexagon, with two vertical sides, and an angle at the top and bottom. The other three lines will be radii drawn from the centre to the lowest angle, and to the two alternate angles; and all these lines and sides will be equal to each other both in the object and representation; and if any other lines parallel to any of

the three radii should exist in the object, and be represented in the picture, their representations will bear to one another, and to the rest of the sides of the cube, the same proportion which the lines represented bear to one another in the object.

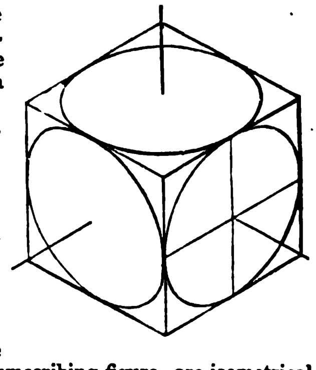
If any one of them, therefore, be so taken as to bear any required proportion to its object, as in the representation of models, the others also will bear the same proportion to their objects; that is, the lines parallel to the three radii will be reduced to a scale.

By the use of the simple apparatus already described, the representation of these lines in the objects may be drawn on the picture, and measured to a scale with the utmost facility: the point at the extremity being first found or assumed. The position of any point in the picture may be easily found by measuring its three distances; namely, first its perpendicular distance from the ***regulating horizontal plane*** (that is, the horizontal plane passing through the regulating point); secondly, the perpendicular distance of that point where the perpendicular meets the dexter line; and, thirdly, of the point where that perpendicular meets the dexter line from the regulating point; and then taking those distances reduced to the scale, first along the dexter line, secondly along the sinister line, and thirdly along the vertical line, in the picture. These three may be called the ***dexter distance*** of the point, its ***sinister distance***, and its ***altitude***. And it is manifest they need not be taken in this order, but in any other that may be more convenient to the artist, there being six ways in which this operation may be performed.

If any point in the same isometrical plane with the point required to be found be already represented in the picture, that point may be assumed as a new regulating point. If it is in the same isometrical line with the point, it is found by taking only one distance. And this last simple operation will be found in practice all that is necessary for the determination of most of the points required. Thus any parallelopiped, or any frame-work or other object with rafters, or lines lying in isometrical directions, may be most easily and accurately exhibited on any scale required. But, if it be necessary to represent lines in other directions, they will not be on the same scale, but may be exhibited, if straight lines, by finding the extremities as above, and drawing the line from one to the other; or sometimes more readily in practice by the help of an ellipse, as hereafter described.

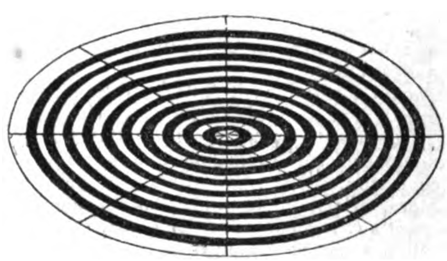
If a curved line be required, several points may be found, each being sufficient to guide the artist to that degree of exactness which is required.

The method of exhibiting the representations of any machines or objects the lines of which lie, as they generally do, in the isometrical direction, that is, parallel to the three directions of the lines of the cube, has been already shown; and likewise the mode of representing any other straight lines by finding their extremities, or curved lines by finding a number of points. But, in representing machines and models, there are not only isometrical lines, but also many wheels working into each other to be represented. These, for the most part, lie in the isometrical planes. And it is fortunate that the picture of a circle in any one of these planes is always an ellipse of the same form, whether the plane be horizontal, dexter, or sinister; yet they are easily distinguished from each other by the position in which they are placed on their axle, which is an isometrical line, always coinciding with the minor axis of the ellipse.



The fact above alluded to will be obvious from considering the figure of a cube with a circle inscribed in each of its planes, and considering these circles as wheels on an axle. The two other lines, (or spokes of the wheel) in the ellipse, which are drawn respectively through the opposite points of contact of the circle with the circumscribing figure, are isometrical lines also; for the points of contact bisect the sides of the circumscribing parallelogram, and therefore the lines are parallel to the other sides. They likewise give the true diameter of the wheels, reduced to the scale required.

The ellipse itself may be drawn by an elliptic compass, as that instrument may be properly set, if the major and minor axes are known. If it be intended to represent a wheel on an axle, care must be taken to make the minor axis lie along that axle. In the absence of the instrument, it may be drawn from the concentric ellipses annexed, which may be placed under the pa-



per, in the position above described, and seen through it if the paper be not too thick; and in this method the smaller concentric circles of the wheel may be described at the same time, as they may be seen through the picture; or, if they should not be exactly of the right size, it would be easy to describe them by hand, between the two nearest concentric ellipses; and thus also the height of the cogs of a wheel in the different parts of it may be exhibited, longer and narrower towards the extremities of the major, and shorter and wider at the extremities of the minor axis. Their width may be determined from the divisions of the ellipse. In most cases, this may be done with sufficient accuracy from the circumference of the ellipse being divided into eight equal divisions of the circle, by the two axes and two isometrical diameters, each of which parts may be subdivided by the skill of the artist; and not only the face of the wheel in front may be thus exhibited, but the parts of the back circles also which are in sight may be exhibited by pushing back the system of concentric ellipses on the minor axis, or axle, through a distance representing the breadth of the

wheel, and then tracing both the exterior and interior circles of the wheel, and of the socket on which it is fixed, as far as they are visible. Care should be taken to represent the top of the teeth, or cogs, by isometrical lines, parallel to the axle, in a face-wheel, or tending to a proper point in the axle in a bevil-wheel. And nearly in the same way may the floats of a water-wheel be correctly represented. If a series of concentric ellipses, such as have been described, be not at hand, it will still be easy for an artist to draw the ellipses with sufficient accuracy for most purposes, by drawing, through the proper point in the axle, the major and minor axes, and two isometrical diameters, thus marking eight points in the circumference to guide him.

If in any case it should become necessary to represent a circle which does not lie in an isometrical plane, we may observe that the major axis will be the same in whatever plane it lies; and it will be the picture of that diameter which is the intersection of the circle with the plane, parallel to the picture, passing through its centre; and the major axis will bear to the minor axis the proportion of radius to the sine of the inclination of the line of sight to the plane of the circle. The representation of every other line parallel and equal to any diameter of the circle may be exhibited by drawing it equal and parallel to the corresponding diameter in the ellipse.

To describe a cylinder lying in an isometrical direction, the circles at its extremities should be represented by the proper isometrical ellipse, and two lines touching both should be drawn; and in a similar way a cone, or frustum of a cone, may be described. A globe is represented by a circle whose radius is the semi-major axis of the ellipse representing a great circle.

It would not be difficult to devise rules for the representation of many other forms which might occur in objects to be represented. But the above cases are sufficient to include almost every thing which occurs in the representation of models, of machines, of philosophical instruments, and indeed of almost any regular production of art.

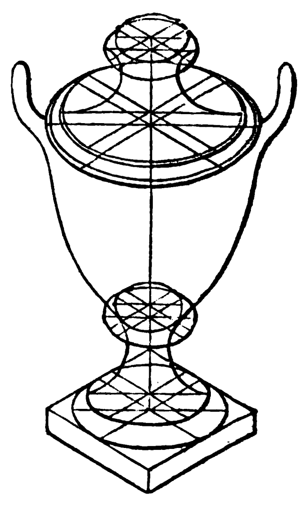
Buildings may be exhibited by this perspective as correctly, in point of measurement, as by plans and elevations, under the advantage of having the full effect of a picture.

A bridge, or any circular or Gothic arch, consisting of portions of circles lying in isometrical planes, may be represented by portions of isometrical ellipses, which will easily be adapted and drawn, upon the principles already explained by which wheels are exhibited on their axles. The centres of these circles must be found, with which the centres of the ellipses must be made to coincide, their minor axes lying along the lines drawn from those centres perpendicular to the planes of the circles.

The shaft of a pillar consists of a frustum of a cone and a cylinder united; or perhaps of a cylinder alone, or a congeries of cylinders: and we have already shown the method of exhibiting these, as well as their bases. And on the same principles the position and size of the volutes and ornaments of the capital may be found, and such guiding points as will make it easy to trace their forms. Thus the different courts and edifices of a cathedral, a college, or a palace, may be correctly depicted; and even the rooms, and internal structure, though less in the form of a picture, may be exhibited in such a way as to enable an architect, or his employer, to contemplate their situation, their ornaments, furniture, or any other circumstance belonging to their appearance; and to mark down exactly what he would have done, in such a way as could hardly be misunderstood by an attentive agent, though at a distance.

In the instances which have been given, most of the lines are isometrical: but the art is applicable to many cases where there are few or none such. It may be necessary, in many of them, to draw isometrical lines, or isometrical ellipses, by way of a guide, to determine the position of certain lines, and points, to enable the artist to describe with accuracy what he has in view: and there is scarcely any form so anomalous as to preclude the artist from taking advantage of these methods of ascertaining such lines or points in it as will give him much assistance in representing it with precision. If the intention be merely to make a picture, the guiding lines may be obliterated as soon as they have served the purpose designed, or they may be retained, in some cases, and their lengths or diameters noted down in figures, if it be wished to give ready information. And often, if the artist wishes to provide materials to enable him, at his leisure, to give accurate descriptions, or exact drawings, the rudest exhibition of such lines may completely serve his purpose, provided he notes down on the spot such measurements with accuracy, however unexact the lines may be on which they are recorded. In many cases it may be expedient to take liberties with this perspective, or with the picture, which will make it suit the purpose designed. And this will produce no confusion, provided those liberties are explained: for instance, it may be often expedient to make the scale in the vertical direction considerably larger than in the horizontal. It may in some cases be necessary to represent on paper what is hid in nature, and what has been said on the internal structure of buildings is an instance of this fact. We shall proceed to give some examples of these observations.

To give such a representation of an Etruscan vase as would enable an artist to model it exactly would be exceedingly easy. Let a vertical line be drawn to represent the axis of the vase, and let points be taken in that axis, corresponding to the centres of the principal circles of the vase, through which the horizontal isometrical lines may be drawn, representing the radii of those circles, by the help of which the isometrical ellipses representing them are easily drawn. These will become a complete guide to the artist. He may assist himself by looking at the object along the line of sight, and then, if he has any skill in drawing, he



will find no difficulty in tracing the outline from one of these to the other, with a sufficient degree of correctness. If he be unskilled in the art, of course he must be at the trouble of finding a larger number of ellipses to guide him. And, in a similar manner, any solid, formed by the revolution of a plane figure round one of its sides, may be represented.

The laying down the timbers of a ship, or making a picture of one, may be adduced as another example. Let a vertical isometrical plane be conceived to pass through its keel, and to be intersected by the perpendicular planes passing through the ribs, and by planes parallel to the decks. The isometrical lines which are the intersections of these may be measured in the ship, and represented, with their proper measures noted down, in the picture, which will afford the means of representing the ribs, and laying them down in their proper places.

If this should be designed for the purpose of constructing a ship from a given model, it might be sufficient to represent the ribs only on one side; those on the other side being the exact counterparts. If the purpose should be to make use of these lines for a drawing, they need be marked but very faintly, and the artist will have little difficulty, when guided by them, to fill up the representation by hand.

ITALIAN SCHOOL, *in the fine arts*. The art of painting was early introduced both into Italy and Germany by Greek masters; but the diversities of national character, climate, and religion, produced different results in the two countries. A glowing imagination, an easy life, an innate sense for the beautiful, enthusiastic piety, the constant sight of nature in her fairest forms, and the contemplation of the masterpieces of ancient art, occasioned painting in Italy to unfold itself with great magnificence; while in Germany the ancient painters loved rather to dwell on the inward life and character. They were poets and philosophers, who selected colours instead of words. The Italians have therefore remained inimitable in the ideal of this art, as the Greeks in statuary. The twelfth century is generally taken as the period of the beginning of the history of painting in Italy; but, even before that time, it had been the scene of the labours of Greek and Byzantine artists.

During the pontificate of Leo the Great, in the year 441, a large picture in mosaic was executed in the Basilica of St. Paul, on the road to Ostia, and the portraits of the forty-two first bishops, which are seen in the same church, date their origin from the same time. Mosaic and encaustic painting were then the prevalent mode. Painting in distemper was afterwards introduced. About the end of the sixth century, there were many paintings which were not believed to be the work of mortal hands, but were attributed to angels or blessed spirits. To this class belongs one of the most famous representations of the Saviour, in wood, at Rome, called *Archeiropoieta*, of which a sight can be obtained only with difficulty in the *sanctum sanctorum*. One of the oldest monuments of art is the celebrated Christ on the Cross, in the Trinity church at Florence, which existed there as early as 1003. About 1200, a Greek artist, Theophanes, founded a school of painting in Venice. The genuine Italian style first developed itself in Florence, and may be treated under three leading periods: 1. from Cimabue to Raphael; 2. from Raphael to the Caracci; 3. from the Caracci to the present time.

First Period. The art was first pursued with zeal in Pisa. Giunta Pisano, Guido of Sienna, Andr. Tafi, and Buffalmaco precede Cimabue, who was born at Florence, in 1240. His scholar Giotto was the friend of Dante and Petrarch, and practised with equal success historical painting, mosaic, sculpture, architecture, and portrait and miniature painting. He first attempted foreshortening and a natural disposition of drapery; but his style, nevertheless, remained dry and stiff. Boniface VIII. invited him to Rome, where he painted the still celebrated Navicella. He was followed by Gaddi, Stefano, Maso, and Simone Memmi, who painted the celebrated portraits of Petrarch and Laura. But Masaccio first dispelled the darkness of the middle ages, and a brighter dawn illumined the art.

The Florentine republic, in the beginning of the fifteenth century, had attained the summit of its splendour. Cosmo of Medici patronized all the arts and sciences; Brunelleschi then built the dome of the cathedral; Lorenzo Ghiberti cast the famous doors of the baptistery in bronze; and Donatello was to statuary what Masaccio was to painting. Masaccio's real name was Tommaso Guidi. He was born at St. Giovanni, in Val d'Arno, in the year 1402. His paintings have keeping, character, and spirit. His scholars first began to paint in oil, but only upon wooden tablets, or upon walls coated with plaster of Paris. Canvass was not used till long after. Paolo Uccelli laid the foundation for the study of perspective. Luca Signorelli, who first studied anatomy, and Domenico Ghirlandaio, who combined noble forms and expression with a knowledge of perspective, and abolished the excessive use of gilding, were distinguished in their profession. The elevated mind of Leonardo da Vinci, who was a master in all the arts and sciences, infused so much philosophy and feeling into the art that, by his instrumentality, it quickly reached maturity. From him the Florentine school acquired that grave, contemplative, and almost melancholy character, to which it originally leaned, and which it afterwards united with the boldness and gigantic energy of Michael Angelo. The Roman school already enumerated among its founders the miniature painter Oderigi, who died in 1300. He embellished manuscripts with small figures. Guido Palmerucci, Pietro Cavallini, and Gentile da Fabriano were his most distinguished successors. Almost all the painters of this time were accustomed to annex inscriptions to their pictures: the Annunciation to the Virgin Mary was their favourite subject. Perugia was the principal seat of the Roman school.

As early as the thirteenth century, there was a society of painters there. Pietro Vanucci, called *Perugino* (who was born 1446, died 1524), first introduced more grace and nobler forms into this school, whose character acquired from him something intellectual, noble, simply pious, and natural, which always remained peculiar to the Roman school. Perugino's great scholar, Raphael, soon surpassed all former masters, and banished their poverty, stiffness, and dryness of style. Taste came into Venice from the East. Andr. Murano and Vittore Carpaccio are among the earliest artists of that city. Giovanni and Gentile Bellino are the most distinguished painters of the earlier Venetian school. The former was born 1424, and

died 1514. The latter laboured some time in Constantinople under the reign of Mohammed II. They introduced the glowing colours of the East; their style was simple and pure, without rising to the ideal. Padua was the principal seat of the Venetian school. Mantegna afterwards transferred it to Mantua, and his style formed the transition to the Lombard school. Schools of painting flourished in Verona, Bassano, and Brescia. Giovanni of Udine (who was so distinguished by his faithful imitation of nature in secondary things that he painted for Raphael the garlands around his pictures in the Farnesina), Pellegrino, and Pordenone, were the most able predecessors of the two great masters of the Venetian school, Giorgione and Titian. No capital city served as the central point of the Lombard school: Bologna subsequently became the centre. Imola, Conto, Ferrara, Modena, Reggio, Parma, Mantua, and Milan, were afterwards considered the seats of this school. Galasio, who lived about 1220, Alighieri, Alghisi, Cosimo Tura, Ercole Grandi, and especially Dosso Dossi, were the principal painters of Ferrara. The last, a friend of Ariosto, possesses a remarkable grandeur of style, united with a richness of colouring which may bear comparison with that of Titian. Bramante, who was likewise a great architect, Lippo Dalmasi, and especially Francesco Raibolini, called *Francesco Francia*, were highly distinguished among the Bolognese masters. The latter, who was marked by a tender religious expression and uncommon industry, had the greatest veneration for Raphael. It is asserted that, at the sight of the St. Cecilia of this master, he was so struck with the impossibility of attaining the same perfection that he fell into a deep melancholy, and soon after died. Here also belongs the charming Innocenzo da Imola. But all these were far surpassed by the incomparable Antonio Allegri da Correggio, who, in fact, first founded the Lombard school, so distinguished for harmony of colours, expression replete with feeling, and genuine grace.

Second Period. We now come to the greatest masters of any age, who almost at the same time, as heads of the four schools, carried every branch of the art to the highest perfection. In Italy, they and their scholars are called *Cinquecentisti*, from the century in which they flourished. This period of perfection passed away rapidly, and soon required the violent restoration with which the third period commences. Next in order after Leonardo da Vinci, who in the Florentine school had settled the proportions of figures and the rules of perspective and of light and shade, may be placed his scholars, Luini, Salaino, and Melzo, besides the admirable Baccio della Porta, who is celebrated under the name of *Fra Bartolommeo*.

We now come to the most extraordinary of all masters, Michael Angelo Buonarotti (born 1474, died 1564). His gigantic mind grasped, with equal power, statuary, architecture, and painting. His fire of composition, his knowledge of anatomy, the boldness of his attitudes and foreshortenings, leave him without a rival; but, as a model, he was detrimental to the art, because his imitators necessarily fell into exaggeration and contempt of a simple style. In grandeur, his fresco painting, the Last Judgment, in the Sistine Chapel at Rome, is inimitable. Beauty was never so much his object as power and sublimity, especially since, in the former, he could not equal Raphael, while in the latter he stood alone. Dante was his favourite poet. In his later years, the erection of St. Peter's church almost entirely engrossed his thoughts. Rosso de' Rossi, Daniel of Volterra, Salviati, Angelo Bronzino, Allessandro Allori, and many others, were his scholars and imitators.

In 1580, Ludov. Cigoli and Greg. Pagani began to awaken a new spirit. They returned to nature, and sought to create a better taste in the *chiaro-oscuro*. Domenico Passignani, Cristoforo Allori, and Comodi were their followers. If we turn our attention to the Roman school, we find at its head the first of artists—Raphael da Urbino. His genius showed itself as elevated in his fresco paintings, in the *stanze* and *loggie* of the Vatican, as it appears lovely, spiritual, and original in the frescos of the Farnesina. No less superior are his oil-paintings, of which we shall only mention his *Madonnas*, celebrated throughout the world, especially the *Madonna del Sisto* (in the Dresden gallery), *the Madonna della Sedia* (in Florence), *Madonna della Pesce* (in Madrid), his St. Cecilia (in Bologna), and his last work, the Transfiguration of Christ. His scholars and successors—the bold Giulio Romano, the more gloomy Franc. Penni il Fattore, the lofty Bartolommeo Ramenghi, surnamed *Bagnacavallo*, Pierino del Vaga, Polidoro da Caravaggio, Gemigniani, Benvenuto Tisi, called *Garofolo*, and many others—were skilful masters; but they forsook the path of their great pattern, and degenerated into mannerism. Frederico Baroccio endeavoured to counteract this tendency. In spirit, he belonged to the Lombard school, as he aimed at the grace of Correggio. He possesses an uncommon degree of grace and expression. With his scholars, Francesco Vanni, Pellegrini, and the brothers Zuccheri, he infused a new life into the Roman school, though the latter produced pleasing rather than great works, and fell into mannerism. Muziano was distinguished in landscape-painting, and Nogari, Pulzone, and Facchetti in portrait-painting.

At the head of the Venetian school, we find two excellent colourists, Giorgione Barbarelli di Castelfranco and Tiziano Vercelli. The portraits of the former are celebrated for their warmth and truth. The latter was great in all the departments of art, inimitable in the disposition of his carnations, excellent as a historical and portrait painter, and the first great landscape painter. Even in extreme old age, his powers were unimpaired. Ariosto and Aretino were friends of the gay-minded Titian. He executed many works for the Spanish kings. Some of his most famous works are the altar-piece of St. Pietro Martire, his pictures of Venus, his Bacchanal, and his Children Playing, in Madrid, his *Cristo della Moneta*, &c. He first understood the art of painting with transparent colours. In groups, he selected the form of a bunch of grapes for a model. His successors—Sebastiano del Piombo, Palma Vecchio, Lorenzo Lotto, Paris Bordone, Pordenone—are distinguished, especially in colouring. Schiavone, whose *chiaro-oscuro* and richness of colour are truly remarkable; Giacomo da Ponto, called *il Bassano*, who imitated reality, even in common things, to deception, and who was the head of a whole family of painters; the ardent, inspired Robusti, called *il Tintoretto*, whom Titian, through jealousy, dismissed from his school; the fantastic, splendid Paul Veronese, who painted boldly and brilliantly with a free pencil, but neglected all propriety of costume, and

frequently mingled masks in historical paintings, and the Veronese Cagliari, were ornaments of the Venetian school. This likewise degenerated, and its mannerists were worse than those of the other schools, because they did not study the antiques and the ideal.

At the head of the Lombard school, we find the charming Antonio Allegri, called *Correggio*, whose works are full of feeling. His successors and scholars were Francesco Rondani, Gatti, Lelio Orsi, and especially Francesco Mazzola il Parmegianino. This artist possessed much ease and a peculiar grace, which frequently bordered on mannerism. Gaudenzio Ferrari, and many others, are the ornaments of the Milanese school. In landscape-painting, Lavizzario was called the *Titian of Milan*. The famous Sofonisba Angosciola, of Cremona, was highly distinguished in music and painting. As an excellent portrait-painter, she was invited to Madrid, where she painted don Carlos and the whole royal family, and gave instruction to queen Elizabeth. Van Dyke declared that he had learned more from the conversation of this woman, when she was blind from age, than he had from the study of the masters. She died in 1620. Lavinia Fontana, Artemisia Gentileschi, Maria Robusti, and Elis. Sirani were celebrated female artists of this time. Camillo and Giulio Procaccino were distinguished for strength of imagination and excellent colouring. In Bologna, we find Bagnacavallo, a distinguished artist of this period, whom we have already mentioned as one of Raphael's scholars. He flourished about 1542. Francesco Primaticcio, Niccolò dell' Abbate, Pellegrino Tibaldi, Passarotti and Fontana were very able Bolognese artists.

Third Period. It begins with the age of the three Caracci. These excellent artists endeavoured to restore a pure style, and, by the combined study of the ancient masters of nature and science, to give a new splendour to the degraded art. Their influence was powerful. The division into the four principal schools now ceases, and we find but two principal divisions—the followers of the Caracci, who are called *eclectics*, and the followers of Michael Angelo Caravaggio, who are called *naturalists*. Ludovico Caracci was the cousin of the two brothers Agostino and Annibale. Ludovico was quiet, contemplative, soft, and serious. His passionate teachers, Fontana and Tintoretto, at first denied him any talent: he studied therefore more zealously, and acquired the deepest views as an artist. Agostino united uncommon sagacity and the most extensive knowledge with a noble character. His brother Annibale, who made extraordinary progress in the art, under Ludovico's direction, became jealous of Agostino. The disputes between the two brothers never ceased, and the offended Agostino devoted himself chiefly to the art of engraving. The attacks of their enemies first united them, and they founded together a great academy. The brothers were invited to Rome to paint the gallery of the duke of Farnese. They soon disagreed, and Agostino retired, leaving the work to his brother, who completed the undertaking with honour, but was shamefully cheated of the greatest part of his pay. Deeply mortified, he sought to divert his mind by new labours and a journey to Naples; but the hostility which he there experienced hastened his death. Meanwhile, with the aid of his scholars, the quiet Ludovico finished one of the greatest works—the famous portico of St. Michael in Bosco, in Bologna, on which are represented seven fine paintings, from the legends of St. Benedict and St. Cecilia. The last of the labours of this great master was the Annunciation to Mary, represented in two colossal figures, in the cathedral of Bologna. The angel is clothed in a light dress, and, by an unhappy distribution of drapery, his right foot seems to stand where his left belongs, and *vice versâ*. Near at hand, this is not observed; but, as soon as the large scaffold was removed, Ludovico saw the fault, which gave occasion to the bitterest criticisms from his enemies. The chagrin which he suffered on this occasion brought him to the grave.

The scholars of the Caracci are numberless. The most famous endeavoured to unite the grace of Correggio with the grandeur of the Roman masters. Cesare Aretusi was distinguished for the most faithful copies of Correggio and Guido Reni, especially for the ideal beauty of his heads, the loveliness of his infant figures, and the uncommon facility of his pencil. His fresco representing Aurora, in the palace Borghese, and his fine oil-painting, the Ascension, in Munich, are well known. Francesco Albani lived in constant rivalry with Guido. He produced many large church paintings, but was most celebrated for the indescribable charm with which he represented, on a smaller scale, lovely subjects from mythology, and especially groups of Cupids. His paintings in the Verospi gallery, and his Four Elements, which he painted for the Borghese family, gained him universal reputation. The back-ground of his landscapes is excellent. All his works breathe serenity, pleasure, and grace. The third great contemporary of those already mentioned, Domenico Zampieri, called *Domenichino*, was at first little esteemed by them, on account of his great modesty and timidity. Thrice were prizes awarded by Ludovico to drawings the author of which no one could discover. At last Agostino made enquiries, and the young Domenichino timidly confessed that the drawings were his. His industry and perseverance rendered him the favourite of his master. His works evince the most thorough knowledge of art, and are rich in expression of character, in force and truth. His Communion of St. Jerome, his Martyrdom of St. Agnes, and his fresco in the Grotta Ferrata, are immortal masterpieces. He was always remarkable for his timidity. He was invited to Naples, but was there persecuted and tormented by the painters; and it is even suspected that he was poisoned.

Giovanni Lanfranco was especially distinguished for the effect of his lights. Bartol. Schidone is one of the best colourists of this school. The Bibienas, the Molas, Al. Tierini, Pietro di Cortona, Ciro Ferri also deserve mention. At the head of the naturalists, who, with a bold and often rash pencil, imitated nature without selection, stands Michael Angelo Merigi, or Amerigi da Caravaggio (born 1569). His chief opponent in Rome was D'Arpino, who stood at the head of the idealists, or rather of the mannerists. Caravaggio and his successors, Manfredi, Leonello Spada, Guercino da Cento, &c., often took common nature for a model, which they servilely imitated, thus profaning the genuine dignity of the art, though they cannot be denied strength and genius. About this time, the beginning of the seventeenth century, the *bambocciate* were introduced. Many artists, especially Michael Angelo Cerquozzi, surnamed *Delle Battaglie*, and *Delle Bambocciate*, followed this degenerate taste. Andrea Sacchi made great efforts to oppose him. His drawing was correct and grand; Raphael was

his model. His most famous scholar was Carlo Maratto (born 1625, at Camerano), whose style was noble and tasteful. The cavaliere Pietro Liberi, Andrea Celesti, the female portrait-painter Rosalba Carriera (born at Venice, 1675, died 1757), who was distinguished for her drawings in crayons, the graceful Francesco Trevisani, Pinzetta Tiepolo, and Canaletto, a painter in perspective, were the most celebrated Venetian painters of this time. Carlo Cignani (born 1628, died at Bologna, 1719), acquired a great reputation by his originality and the strength and agreeableness of his colouring. Of his scholars, Marc. Antonio Franceschini was distinguished (born 1648, died 1729), whose works are charming and full of soul.

Giuseppi Crespi, called *Spagnoletto*, deserves mention for his industry and correct style, but his pictures have unfortunately become very much defaced by time. Among the Romans, Pompeo Battoni (born 1708, died 1787) was principally distinguished, and was a rival of the celebrated Mengs. Angelica Kaufmann also deserves to be mentioned.

We must not forget the Neapolitan and the Genoese schools. Of the Neapolitans, we name Tommaso de' Stefani (born 1230), Fil. Tesauro, Simone, Colantonio de' Fiori (born 1352), Solario il Zingaro, Sabatino (born 1480), Belisario, Caracciolo, Giuseppe Ribera Spagnoletto (born 1593), Spadaro, Francesco di Maria (born 1623), Andrea Vaccaro, the great landscape-painter Salvator Rosa (born 1615), Preti, called *il Calabrese* (born 1613), and Luca Giordano (born 1632, died 1705), who was called, from the rapidity of his execution, *Luca fa Presto*. Solimena (born 1657) and Conca belong to the modern masters of this school. The Genoese can name among their artists Semino (born 1485), Luca Cambiasi (born 1527), Paggi Strozzi, called *il Prete Genovese*, Castiglione (born 1616), Biscaino, Gaulli, and Parodi. Perhaps the most distinguished of the living painters of Italy is Camoccini. This reputation, however, is not allowed him without dispute by foreign countries, and even by many artists of his native land. His style is grand, and purely historical; his drawings are even more highly esteemed than his paintings. His pieces, however, are cold, and their estimation seems to have diminished. The pencil of Grassi possesses an inimitable grace, and a true enchantment. Benvenuti, director of the academy in Florence, is the first artist there. Appiani, who died a few years ago at Milan, was particularly celebrated for the grace of his female figures; and Bossi had equal reputation in a more serious and severe style. The Florentine Sabbatelli's sketches with the pen are highly esteemed.

In the art of engraving, the Italians have acquired great eminence. Tommaso Finiguerra, who flourished 1460, was the first celebrated master of this art, which he taught to Baccio Bandini. They were succeeded by Mantegna; but Marco Antonio Raimondi, of Bologna, who lived in 1500, was the first to introduce greater freedom of style into his engravings. His copies of Raphael have always been highly valued, on account of their correctness. His manner was imitated by Bonasone, Marco di Ravenna, Di Ghisi, and others. Agostino Caracci, Parmeggiano, Carlo Maratti, and Pietro Testa, etched some excellent works. Stefano della Bella was distinguished for his small, spirited, and elegant pieces. Among the moderns, Bartolozzi deserves mention in stippled engraving. Cunego, Volpato, and Bettelini are also distinguished; but, above all, the Florentine Raphael Morghen, who carried the art of engraving to a degree of perfection never before anticipated. The labours of Morghen, and yet more those of Longhi (perhaps the most admirable of all modern engravers), of Toschi, of Anderloni, of Folo, of Palmerini, of Lasinio, of Caravaglia, Lapi, and Schiavonetti, evince an activity to which new employment and new excitement have been afforded by the eagerness of travellers to procure their works. One of the latest and best is the work of the brothers Durelli, *La Certosa di Pavia*. The painter Francesco Pirovano, whose description of Milan exceeds all others in exactness, has also given us a description of this celebrated Carthusian monastery.

As a medium between painting and sculpture, we must mention mosaic, in which many paintings have been imitated in Italy, from the wish to render the master works imperishable. There is a distinction made between the Roman mosaic executed by Tafi, Giotto, and Cavallini, and the Florentine. (See Mosaic.) Mosaic painting seems to have flourished as well in France, whither it was transplanted, as in Rome. The art of working in *scagliola* (see Scagliola) has flourished for two centuries in Tuscany. In later times, Lamberto Gori has distinguished himself in this branch. Rome is still the metropolis of the arts.

Pope Pius VII. generously supported the plans of that lover of the arts, Cardinal Gonsalvi; and the Chiaramonti museum, the most superb part of the long galleries of the Vatican, will be a lasting monument of his noble patronage. All friends of the sublime and beautiful deeply felt the accident that befel St. Paul's church, near Rome, in the conflagration of 1823. To restore it would hardly be possible. The loss of this noble Basilica is not adequately compensated by the church of St. Peter and Paul, built opposite the castle of Naples, nor by the temple of Possagno, which, before it was finished, received the ashes of its founder, the great Canova. As a monument to the embellishment of which that distinguished man contributed the last efforts of his genius, this church is a legacy highly to be esteemed by Italian artists. Sculpture and painting here again meet architecture in a sisterly embrace. Canova's death was the cause of its first solemn consecration. Notwithstanding the excellence of their master, little is to be expected from the Italians of Canova's school. The monuments which were executed or planned by Ricci for the present grand-duke of Tuscany, at Arezzo, by Pisani for the princesses of the house of Este at Reggio, and by Antonio Bosa to the memory of Winckelmann, rather depress our hopes than exalt them. The principal ground of hope of future excellence is in the love which has been generally awakened for the plastic arts. Gem engraving has been carried to a very high degree of perfection; and Bernini's labours well merit the wide reputation which they have acquired.

Italian School, *in music*; the style of music now prevalent in Italy is characterized by the predominance of melody and song to the neglect of harmony, and is in this respect distinguished from the old Italian music. Like other branches of modern art, the music of modern times sprung from religion. The history of the art, after pointing out a few imperfect glimmerings of ancient music, conducts us to Italy,

where, in the course of centuries, the ancient was first lost in the modern. Here we first find the proper choral song, the foundation of modern church music, which was at first sung in unison, chiefly in melodies derived from the old Greco-Roman music, and adapted to Christian hymns and psalms. (See MUSIC, and MUSIC, SACRED.) It seems to have had its origin when Bishop Ambrosius, in the fourth century, introduced into the western church songs and hymns adapted to the four authentic modes of the Greeks, and appointed psalmists or precentors. Gregory the Great, in the sixth century, enlarged the choral song by the plagal modes. From this time, singing-schools were multiplied, and much was written upon music. The most important inventions for the improvement of music generally we owe to the eleventh century, and particularly to the Benedictine Guido of Arezzo, who, if he did not invent the mode of writing musical notes and the use of the clef, improved and enlarged them, determined the exact relations of the tones, named the tones of the scale, and divided the scale into hexachords.

In the thirteenth century, the invention of music in measure was spread in Italy, dependent upon which was that of counterpoint and figured music. Instruments were multiplied and improved in the fourteenth and fifteenth centuries. Many popes favoured music, particularly vocal, and consecrated it by their briefs; yet the ecclesiastical ordinances restrained the independent developement of music. Much instruction was given in singing in the fifteenth century, and not entirely by monks. Music acquired the rank of a science, and vocal music in counterpoint was developed.

In the sixteenth century, we discover distinguished composers and musicians—Palestrina, composer for the chapel of Pope Clement XI., whose works possess great dignity and scientific modulation, and his successors, Felice Anerio, Nanino da Vallerano, who, together with Giovanni da Balletri, were considered as distinguished musicians; also the celebrated contrapuntist and singer, Gregorio Allegri, and the great writer upon harmony, Giuseppe Zarlino, chapel-master at Venice. Music at Rome and Venice was cultivated with the greatest zeal. Hence it went to Naples and Genoa; and Italy, Schubert says, was soon one loud-sounding concert-hall, to which all Europe resorted to hear genuine music, particularly beautiful singing. In the seventeenth century, we meet with the first profane music. The first opera was performed at Venice 1624, at first with unaccompanied recitatives and chorusses in unison; it spread so quickly that the composers of spectacles were soon unable to supply the demands of the people, and from forty to fifty new operas appeared yearly in Italy. This caused great competition among the Italian musicians. Thus the peculiar character of the Italian music, not to be changed by foreign influence, was developed the more quickly, because this species was cultivated independently, and unrestrained by the church. Already, in the middle of the seventeenth century, when the music of the theatre was continually advancing, simplicity began to give place to pomp and luxuriance, and the church style to decline. Music (says Schubert) united the profane air of the drama with the fervour of the church style, and this was the first cause of the decline of the latter.

Let us now consider the principal periods of the dramatic style. Vocal music must have been first; it was regulated by the discovery and improvement of instruments; thence arose the simple, grand church music of the fifteenth and sixteenth centuries; with it various forms of national song were developed. On the stage, the higher style of music flourished independently. Here the Italian, without much attention to the poetical part of the performance, which was, indeed, only the hasty work of a moment, followed his inclination for melody and sweet sounds, which appears even in his language.

All the southern nations show a great sensitiveness, and melody is to them as necessary as harmony to the inhabitants of the North; but to no nation so much as to the Italians, whose beautiful climate and happy organization for song made melody their chief aim in their music. On the other hand, the simplicity of melody degenerated into effeminacy and luxuriance from the time when vocal music developed itself independently, and the voice, being but little supported by instrumental music, began to be cultivated like an instrument. Poetical expression and truth gave place to mere gratification of the ears, and deep emotion to a momentary excitement: a rapid change of tones, with the avoidance of all dissonance, was principally desired. At this time music began to predominate over poetry in dramatic representations, and the musical part of the performance obstructed the improvement of the dramatic and poetic. This taste spread over other countries so much the more easily from Italian music having advanced, by rapid strides, far before that of the rest of Europe, as appears even from the predominance of Italian terms in musical language. This artificial developement of the song was promoted by the introduction of soprano singers on the stage, which destroyed the possibility of poetic truth in dramatic representation. The voice was cultivated to the highest degree by means of the numerous conservatorios and singing schools. To this was added the great encouragement and the extravagant rewards of distinguished singers; the great opportunities afforded for singing (as every place of consequence in Italy had its theatre, and many had several); besides which, music is an essential part of the service of the Catholic church, and castration was permitted *ad honorem Dei*, as a papal brief expresses it. The excessive culture of the voice must necessarily lead to the treatment of it as an instrument, to the neglect of poetical expression. Instrumental music, too, in this case, necessarily becomes subordinate. The latter should not indeed overpower the song, as is the case in much of the French and German music; but, in the Italian music, the composer is almost restricted to showing off the singer, and cannot develope the fulness and depth of harmony which depends upon the mingling of consonance and dissonance. This is the reason why the masterpieces of Mozart have never entirely satisfied the Italians. Among the best composers, since the seventeenth century, are Girolamo Frescobaldi, Francesco Foggia, Bapt. Lully, the celebrated violinist and composer Arcangelo Corelli. To the singers, of whom the most were also composers, belong Antimo Liberati, Matteo Simonelli, both singers in the chapel of the pope.

In the beginning of the eighteenth century, Ant. Caldara was distinguished. He increased the effect of vocal music by the addition of instruments, but his tyle partook much of the theatrical. There were,

besides, Brescianello, Toniri, and Marotti. In the middle of this century, Italian music, especially theatrical, flourished, particularly at Naples, Lisbon, and also in Berlin. This has been considered by some as the most brilliant period of Italian music. Among the composers of the eighteenth century are mentioned Traelta, who, through his refinements, injured the simplicity of composition; Galuppi, distinguished by simple and pleasing song, rich invention, and good harmony; Jomelli, who gave greater importance to instrumental music; Maio; Nic. Porpora, the founder of a new style of singing, distinguished for his *solfeggios* in church music; Leo; Pergolesi, whose music is always delightful, from its simple beauty; Pater Martini, at Bologna; the sweet Piccini, rival of Gluck; and Anfossi. Of a later date are Paesiello Cimarosa, the ornament of the *opera buffa*, and Zingarelli, Nasolini, Paganini, Niccolini, Pavesi, and the now much celebrated Generali and the copious Rossini. The Italian school is yet unequalled in whatever depends upon the mere improvement of the voice; but the slavish imitation of their manner leads to affectation, and the English singers should employ it no farther than they can without losing the spirit and poetical expression which all vocal music aims at.

IVORY; the substance of the tusk of the elephant. Ivory is esteemed for its beautiful cream colour, the fineness of its grain, and the high polish it is capable of receiving. That of India is apt to lose its colour and turn yellow; but the ivory of Achem and Ceylon is not chargeable with this defect. Ivory is used as a material for toys, and for panels in miniature painting, &c.

The shavings of ivory may be reduced into a jelly, of a nature similar to that of hartshorn; or, by burning in a crucible, they may be converted into a black powder, which is used in painting, under the name of *ivory-black*. Ivory may be stained or dyed; a black colour is given it by a solution of iron and a decoction of logwood; a green one by a solution of verdigris; and a red by being boiled with Brazil-wood, in lime-water.

The use of ivory was well known in very early ages: we find it employed for arms, girdles, sceptres, harnesses of horses, sword-hilts, &c. The ancients were also acquainted with the art of sculpturing in ivory, of dyeing and encrusting it. Homer refers to the extreme whiteness and beauty of ivory. The coffer of Cypselus was doubtless the most ancient monument of this kind in basso-relievo, and we meet with similar instances in the temple of Juno at Olympius, in the time of Pausanias; that is to say, 700 years after it had been built. The ancients had numerous statues of ivory, particularly in the temples of Jupiter and of Juno, at Olympius. In these statues, there was very frequently a mixture of gold. The most celebrated are stated to have been the Olympian Jupiter and the Minerva of Phidias: the former was covered with a golden drapery, and seated on a throne formed of gold, of ivory, and cedar wood, and enriched with precious stones. In his hand the god held a figure of Victory, also of ivory and gold. The Minerva was erected in the Parthenon at Athens during the first year of the eighty-seventh Olympiad—the year which commenced the Peloponnesian war. Pausanias likewise makes mention of an ivory statue of Juno on her throne, of remarkable magnificence, by Polycletes, together with numerous others.

JALAP has received its name from being principally brought from the environs of Xalapa; though the plant which produces it is abundant in other parts of Mexico, even in the immediate vicinity of Vera Cruz. It is much employed in medicine, as a very valuable purgative, and has been known in Europe since the year 1610. It is exported almost exclusively from Vera Cruz, to the amount of about 400,000 lbs. annually. The root, which is the part employed, is very large, sometimes weighing fifty pounds.

JAPANNING is the art of varnishing in colours. All substances that are dry and rigid, or not too flexible, admit of being japanned. Wood and metals require no other preparation than to have their surfaces perfectly even and clean; but leather should be securely stretched, either on frames or on boards, as its bending would crack and force off the varnish. Paper should be treated in the same manner, and have a previous strong coat of size; but it is rarely japanned till converted into *papier maché*, or wrought into such form that its flexibility is lost. The article to be japanned is first brushed over with two or three coats of seed lac varnish, to form the *priming*. It is then covered with varnish, previously mixed with a pigment of the tint desired. This is called the *ground colour*; and, if the subject is to exhibit a design, the objects are painted upon it in colours mixed with varnish, and used in the same manner as for oil-painting. The whole is then covered with additional coats of transparent varnish, and all that remains to be done is to dry and polish it. Japanning requires to be executed in warm apartments, and the articles are warmed before the varnish is applied to them. One coat of varnish also must be dry before another is laid on. Ovens are employed to hasten the drying of the work. The same pigments which are employed in oil or water answer also in varnish. For painting figures, shell lac varnish is considered best, and easiest to work; it is therefore employed in most cases where its colour permits. For the lightest colours, mastic varnish is employed, unless the fineness of the work admits the use of copal dissolved in alcohol.

JAUNDICE is a disease of which the distinguishing peculiarity is that the whole skin becomes yellow. It proceeds from some disease about the liver, or its communication with the bowels. The internal symptoms are those of all disorders of the digestive organs, except that the water is dark and loaded with bile, while the bowels appear to be deprived of it. The yellow colour is first perceptible in the whiter parts of the body, as the white of the eye, &c., and soon overspreads the whole body. There is often an extreme itching and pricking over the whole skin. After the disease has continued long, the colour of the skin acquires a deeper and darker tint, till the disease becomes, at last, what is vulgarly called the *black jaundice*. This appearance arises from the bile being retained, from various causes, in the liver and gall-bladder, and thus being absorbed and circulated with the blood. It may be produced by obstacles to the passage of the bile of various kinds, and is often suddenly induced by a violent fit of passion, or more slowly by long continuance of melancholy and painful emotions. It is a very common figure of speech to say that "a person views a thing or a person with jaundiced eyes;" but this is founded in a mistake; for it is not true that jaundice communicates such a colour to the transparent part of the

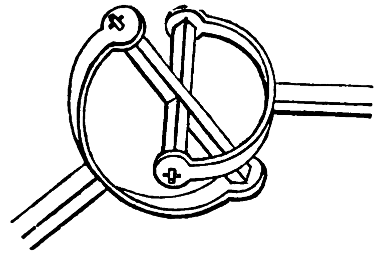
eye as to affect the colour of objects. The above phrase is therefore inappropriate.

Jelly includes every translucent juice so far thickened as to coagulate, when cold, into a trembling mass; as the juices of acid or mucilaginous fruit, currants, &c., which, by the addition of one part of sugar to two parts of juice, and by boiling, have obtained a proper consistence; also a concentrated decoction of Iceland moss, made agreeable to the taste by the addition of sugar or liquorice; also strong decoctions of the horns, bones, or extremities of animals, boiled to such a degree as to be stiff and firm when cold, without the addition of any sugar.

The jellies of fruits are cooling, saponaceous, and acescent, and therefore are good as medicines in all disorders of the *primæ viæ*, arising from alkalescent juices, especially when not given alone, but diluted with water. On the contrary, the jellies made from animal substances are all alkalescent, and are therefore good in all cases in which an acidity of the humours prevails. The alkalescent quality of these is however, in a great measure, taken off, by adding lemon-juice and sugar-lemon to them. There was formerly a sort of jellies much in use, called *compound jellies;* these had the restorative medicinal drugs added to them, but they are now scarcely ever heard of. Animal jelly is soluble in water, glutinous, becomes fluid by heat, coagulates in the cold, combines with oils and resins, is decomposed by corrosive alkali, and gives out ammonia; when it is treated with nitric acid, it yields oxalic acid, and, under dry distillation, yields the products obtainable from all animal substances, and can be changed into a perfectly dry substance by evaporation.

Jet. The colour of jet is a pure and deep black, sometimes with a tinge of brown. It occurs in opaque, compact masses, so solid and hard that they are susceptible of being turned on a lathe and highly polished. Its fracture is conchoidal or undulated, shining or even splendent, and it has a resinous lustre; its specific gravity, from 1.25 to 1.30. By friction, it acquires a weak electricity, even when not insulated. It sometimes presents the form of branches of trees, and exhibits traces of a ligneous texture. It burns with flame, often a little greenish, but it does not melt, like solid bitumen. It exhales, while burning, a strong and sometimes aromatic odour, sensibly different from that of coal or bitumen. It most frequently occurs in detached masses of a moderate size, in beds of sandstone, marl, limestone, and secondary trap. Jet is sometimes employed for fuel, but is more frequently cut and polished, for ornamental purposes, buttons, bracelets, snuff-boxes, &c. Some mineralogists consider it intermediate between coal and bituminous wood.

Joint, in *mechanics;* the connecting point of any movable machine. The various joints employed in the human frame are all of the most perfect kind, though they differ considerably in their structure. The mechanic has however copied but two, the *hinge*, and the *ball and socket*. The hinge-joint is used for doors, and those places generally which require motion but in one direction. The ball and socket, on the contrary, admits of a variety of positions. The expense attendant on constructing the latter is very considerable, and to obviate this inconvenience the *Hook's-joint* represented in the accompanying engraving may be employed. It was originally invented by Dr. Hook, and is found very useful in communicating a rotatory motion from the principal axis of a machine to the more distant wheels it is intended to put in operation.



It consists of two semicircles, joined by a metal cross; and, if either of the semicircles be turned, a similar motion is communicated to the other. The same species of universal joint is employed to support a compass at sea. It is then called a *jimbel-box*.

Joint-Stock Companies. Where any branch of business requires a greater capital to prosecute it with advantage than can ordinarily be furnished by an individual or by a number of individuals actually engaged in conducting it, or where the business is attended with great risks, and may, as events turn out, be very profitable, or result in great losses, as in the case of insurance, it is desirable that the law should give facility to the combination of the contributions of numerous persons, in great or small amounts, to make up the requisite capital. The first and most obvious combination for the purposes of business is that of copartnerships, whereby each of the members renders himself answerable, *in solido*, or absolutely and to the full extent, on all contracts made by the company. This is a sort of association existing in all places; but, if the business to be conducted be of the descriptions above mentioned, the copartnership is not a convenient mode of association, since the capital contributed by many must necessarily be managed by a few; and therefore, if each member is liable, *in solido*, on the contracts of the company, the fortune of each is put in jeopardy by ever so small a contribution to the joint stock. This must operate, of course, to discourage useful undertakings on a large scale, and, even if it did not, it might still be very important to provide for associations with a limited liability of the individual members, since the ruin of any individual will necessarily affect others to a greater or less extent.

The shocks, and individual derangements and reverses, which are necessarily incident to enterprises of industry and trade, make it very desirable to secure, by some modes of association, an apportionment of risks, losses, and gains among a great number. This is done by means of private corporations, joint-stock companies, and limited copartnerships.

Journal, in *navigation;* a sort of diary or daily register of the ship's course and distance, the winds and weather, together with a general account of whatever is material to be remarked in the period of a sea voyage, such as the shifting, reducing, or enlarging the quantity of sail, the condition of the ship and her crew, the discovery of other ships or fleets, lands shoals, breakers, soundings, &c.

Journeyman, formed from the French *journée* (a day's work), anciently signified a person who wrought with another by the day; but it is now used to designate any mechanic who works for another in his em-

ployment, whether by the month, year, or any other term. It is applied only to mechanics in their own occupations.

JUGERUM; a Roman measure; a piece of ground which could be ploughed in one day by a yoke of oxen; a Roman acre, 240 feet long, 120 feet broad (28,800 square feet). It was the unit of field-measure, and divided into ½ *jugerum* = 14,400 Roman square feet; ⅛ *jugerum* = 3600. *Actus minimus* was a strip 4 feet wide and 120 feet long = 480 Roman square feet. Two *jugera* were called *hæredium;* 100 *hæredia* made one *centuria*, and four *centuriæ* (= 800 *jugera*) one *saltus*. In the time of the kings, two *jugera* were reckoned a sufficient allowance for a father of a family; at a later period, seven; 376 B. C., fifty; but, even at a still later period, it was considered dishonourable for a senator to possess more than 500 *jugera*.

JULY; the seventh month in our calendar, which, in the Roman year, bore the name of *Quintilis*, as the fifth in the computation of Romulus, even after Numa had prefixed January and February. Marc Antony effected a change in its name, in honour of Julius Cæsar, who was born IV. *Idus Quintilis*, and thenceforward, by a decree of the senate, it was called *Julius*.

JUNE; the sixth month in our calendar. Vossius gives three etymologies of the name—one from *Juno;* another from *jungo* (to join), referring to the union between the Romans and Sabines, under Romulus and Titus Tatius; a third from *juniores* (the young men), Romulus having been said to have assigned the month of May to the elders and that of June to the young men, when he divided the people into these two great classes, the former to serve in counsel, the latter in war. These origins are more fully explained by Ovid. The name has also been traced to Junius Brutus, the first consul.

JUNIPER. The berries of this plant are made use of to impart their peculiar flavour to spirit, constituting *gin*. They are also used by brewers, to give pungency to the lighter kinds of beer. In some parts of Europe, they are roasted, ground, and used as a substitute for coffee. They are also used in Sweden and in Germany as a conserve, and as a culinary spice, and especially to give flavour to sour-crout. Like all plants of the terebinthinate class, they have a decidedly diuretic property, and they are much used as diuretic medicines. The oil of juniper, if mixed with nut-oil, forms an excellent varnish for pictures, woodwork, and iron, which it preserves from rust. From the bark exudes a resinous gum, known by the name of *gum sandarach*. It is in small yellow pieces, very brittle and inflammable, and of a pungent aromatic taste. When finely powdered and sifted, it constitutes the substance so well known under the name of *pounce*. It is also used by painters in the preparation of varnish, especially of the kind termed *vernix*.

JURY-MAST; a temporary or occasional mast, erected in a ship in the place of one that has been carried away by tempest, battle, &c. Jury-masts are sometimes erected in a new ship, to navigate her down a river, or to a neighbouring port, where her proper masts are prepared for her.

KALEIDOSCOPE; an instrument for creating and exhibiting an infinite variety of beautiful forms, pleasing the eye by an ever-varying succession of splendid tints and symmetrical figures, and enabling the observer to render permanent such as may appear appropriate for any branch of the ornamental arts. This instrument, the invention of Doctor Brewster, in its most common form consists of a tin tube, containing two reflecting surfaces, inclined to each other at any angle which is an aliquot part of 360°. The reflecting surfaces may be two plates of glass, plain or quicksilvered, or two metallic surfaces, from which the light suffers total reflection. The plates should vary in length, according to the focal distance of the eye: five, six, seven, eight, nine, and ten inches, will, in general, be most convenient; or they may be made only one, two, three, or four inches long, provided distinct vision is obtained at one end, by placing at the other an eye-glass, whose focal length is equal to the length of the reflecting planes. The inclination of the reflector that is in general most pleasing is 18°, 20°, or 22½°, or the 20th, 18th and 16th part of a circle; but the planes may be set at any required angle, either by a metallic, a paper, or cloth joint, or any other simple contrivance. When the two planes are put together, with their straightest and smoothest edge in contact, they will have the form of a book opened at one side. When the instrument is thus constructed, it may be covered up either with paper or leather, or placed in a cylindrical or any other tube, so that the triangular aperture may be left completely open, and also a small aperture at the opposite extremity of the tube. If the eye be placed at the aperture, it will perceive a brilliant circle of light, divided into as many sectors as the number of times that the angle of the reflectors is contained in 360°. If this angle be 18°, the number of sectors will be 20; and, whatever be the form of the aperture, the luminous space seen through the instrument will be a figure produced by the arrangement of twenty of these apertures round the joint as a centre, in consequence of the successive reflections between the polished surfaces. Hence it follows that if any object, however ugly or irregular in itself, be placed before the aperture, the part of it that can be seen through the aperture will be seen also in every sector, and every image of the object will coalesce into a form mathematically symmetrical, and highly pleasing to the eye. If the object be put in motion, the combination of images will likewise be put in motion, and new forms, perfectly different, but equally symmetrical, will successively present themselves, sometimes vanishing in the centre, sometimes emerging from it, and sometimes playing around in double and opposite oscillations. When the object is tinged with different colours, the most beautiful tints are developed in succession, and the whole figure delights the eye by the perfection of its forms and the brilliancy of its colouring. The eye-glass placed immediately against the end of the mirrors, as well as another glass similarly situated at the other end, is of common transparent glass. The tube is continued a little beyond this second glass, and, at its termination, is closed by a ground glass, which can be put on and off. In the vacant space thus formed, beads, pieces of coloured glass, and other small bright objects, are put. The changes produced in their position, by turning the tube, give rise to the different figures.

A very beautiful instrument may be constructed by combining the kaleidoscope with a movable pendulum. The kaleidoscope should be fixed in such a direction as to present the open end to the light, and, instead of loose objects, some twisted glass of different colours must be attached to the pendulum.

As the latter vibrates before the instrument the most brilliant and symmetrical figures are formed.

KEDGE, or KEDGER; a small anchor, used to keep a ship steady, and clear from her bower-anchor, while she rides in a harbour or river, particularly at the turn of the tide, when she might otherwise drive over her principal anchor, and entangle the stock or flukes with her slack cable, so as to loosen it from the ground. The kedge-anchors are also used to transport a ship, or remove her from one part of a harbour to another, being carried out from her in the long-boat, and let go by means of ropes fastened to these anchors. They are also generally furnished with an iron stock, which is easily displaced for the convenience of stowing.

KEEL; the principal piece of timber in a ship, which is usually first laid on the blocks in building. By comparing the frame of a ship to the skeleton of the human body, the keel appears as the back-bone, and the timbers as the ribs. The keel supports and unites the whole fabric, since the stem and stern-posts, which are elevated on its ends, are, in some measure, a continuation of the keel, and serve to connect and enclose the extremities of the sides by transoms, as the keel forms and unites the bottom by timbers. The keel is generally composed of several thick pieces placed lengthways, which, after being scarfed together, are bolted and clinched upon the upper side.

False keel; a strong, thick piece of timber, bolted to the bottom of the keel, which is very useful in preserving its lower side. The false keel is provided when the thick pieces which form the real keel cannot be procured large enough to give a sufficient depth thereto. In large ships of war, the false keel is composed of two pieces, called the *upper* and *lower* false keels. The lowest plank in a ship's bottom, called the *garboard streak*, has its inner edge let into a groove or channel, cut longitudinally on the side of the keel: the depth of this channel is therefore regulated by the thickness of the garboard streak.

Sliding Keels are found very advantageous. They are attached by timbers to the bottom of the vessel, and may be raised or depressed at pleasure. When a vessel constructed in this way enters shallow water the keel is raised: but when navigating the ocean, and carrying a press of sail, the keel is depressed, and the vessel thus rendered more stable.

KEELSON, or KELSON; a piece of timber forming the interior or counter part of the keel, being laid upon the middle of the floor-timbers, immediately over the keel, and serving to bind and unite the former to the latter, by means of long bolts driven from without, and clinched on the upper side of the keelson. The keelson, like the keel, is composed of several pieces scarfed together; and, in order to fit with more security upon the floor-timbers and crotchets, it is notched about an inch and a half deep, opposite to each of those pieces, thereby scored down upon them to that depth, where it is secured by spike-nails. The pieces of which it is formed are only half the breadth and thickness of those of the keel.

KEEP, in the *military art;* a kind of strong tower, which was built in the centre of a castle or fort, to which the besieged retreated, and made their last efforts of defence. It was also called the *donjon* or *dungeon.*

KEEPING, in *painting*, is a technical term, which signifies the peculiar management of colouring and *chiaro-oscuro*, so as to produce a proper degree of *relievo* in different objects, according to their relative position and importance. This may be effected either by shade or colour, either by throwing a shadow across the inferior objects, or by tinting them with a colour less bright than that given to others, and, in very skilful hands, it may even be done by the directly reverse practice. As the objects recede in the ground plane, the hue of the atmosphere, intermixing with their *proper* or *local* colour, as it is termed, will assist in their keeping. On keeping, *relievo* entirely depends; for, if the lights, shadows, and half tints be not kept in their exact relative proportions of depths, no rotundity can be effected, and without due opposition of light, shade, and colours, no apparent separation of objects can take place. Raphael has, in two instances, totally failed of proper keeping—in the Transfiguration, and the Miraculous Draught of Fishes.

KELP, in *commerce;* the ashes of sea-weeds or *fuci*. The sea-weed is cut close to the rocks, during the summer season, and afterwards spread out upon the shore to dry, care being taken to turn it occasionally, to prevent fermentation. It is then stacked for a few weeks, and sheltered from the rain, till it becomes covered with a white saline efflorescence, and is now ready for burning. This is usually accomplished in a round pit, lined with brick or stone; but the more approved form for a kiln is oblong, about two feet wide, from eight to eighteen long, and from two to three deep: the bottom of this is covered with brush, upon which a little dried sea-weed is scattered, and fire is applied at one extremity; the sea-weed is then thrown on gradually, as fast as the combustion reaches the surface, and, should there be much wind, it will be necessary to protect it by covering the sides with sods. After the whole is burnt, the mass gradually softens, beginning at the sides, when it should be slowly stirred up with a heated iron bar, and incorporated, till it acquires a semifluid consistence. This part of the process requires considerable dexterity; and, if the mass continue dry, a little common salt should be thrown on, which acts as a flux. When cold, it is broken up, and is then ready for sale.

Notwithstanding that kelp contains but two or three per cent. of carbonate of soda, while Spanish barilla often contains twenty or thirty, the manufacture of this article has increased prodigiously on the northern coasts of Great Britain and the neighbouring islands. Farms in the Orkneys which formerly rented for 40*l.* a year have now risen to 300*l.*, on account of their kelp shores; and so much importance is attached to this branch of business that, along sandy shores, stones have been placed within the flood-mark, which, in a short time, become covered with seaweed. Many thousand tons are thus manufactured annually, and are sold in the various ports of Great Britain. The uses of soda are, in general, the same with those of potash; but there are certain branches of manufactures to which it is indispensable, as to the making of plate and crown glass, and all hard soaps. Both alkalies are consumed in immense quantities by soap-boilers, bleachers, and glass-makers; but it is said that in France the use of potash has very much diminished since the culture of barilla has been introduced. The barilla obtained in France from the *salicornia annua* yields fourteen or fifteen per cent. of soda; while that from *salsola tragus* yields only from three to eight per cent. The Spanish barilla is the most esteemed, particularly that from Alicant. It is

obtained from the *salsola sativa*, which is carefully cultivated in light, low soils, embanked on the side next the sea, and furnished with flood-gates, through which the salt water is occasionally admitted. So anxious are the Spaniards to monopolize this trade that the exportation of the seed is prohibited under pain of death. Carbonate of soda is also found abundantly in a mineral state in many countries, as in Hungary, the southern parts of Siberia, Persia, China, North Africa, and the environs of Smyrna; but the native salt has not hitherto become important as an article of commerce.

KETCH; a vessel equipped with two masts, viz. the main-mast and the mizzen-mast, and usually from 100 to 250 tons burden. Ketches are likewise used as bomb-vessels, and are therefore furnished with all the apparatus necessary for a vigorous bombardment.

Bomb-ketches are built remarkably strong, as they are fitted with guns of a much larger caliber than any other vessel of war; and, indeed, this reinforcement is absolutely necessary to sustain the violent shock produced by the discharge of their mortars, which would otherwise, in a very short time, shatter them to pieces.

KETCHUP, or CATSUP. Doctor Kitchiner, in his *Apicius Redivivus*, devotes ten pages to different varieties of receipts for this sauce. There we may become acquainted with the composition and virtues of numerous catsups, whether they be walnut, mushroom, quintessence of mushroom, quintessence of oysters, cockle, muscle, tomato, white cucumber, or pudding. "Mushroom gravy," says the doctor, "approaches the flavour of meat gravy more than any other vegetable juice, and is the best substitute for it in meagre soups and *extempore* gravies." Again, "What is commonly called *catsup* is generally an injudicious composition of so many different tastes that the flavour of the mushroom is overpowered by a farrago of garlic, shallot, anchovy, mustard, horseradish, lemon-peel, beer, wine, and spices. Ready-made catsup is little better than a decoction of spice, and salt and water, with the grosser part of the mushrooms beaten up into a pulp."

KEY, or KEY NOTE, in *music*; a certain fundamental note or tone, to which the whole of a movement has a certain relation or bearing, to which all its modulations are referred and accommodated, and in which it both begins and ends. There are but two species of keys; one of the major, and one of the minor mode, all the keys in which we employ sharps or flats being deduced from the natural keys of C major and A minor, of which they are mere transpositions.

KEYS of an organ; movable projecting levers in the front of an organ, so placed as to conveniently receive the fingers of the performer, and which, by a connected movement with the valves or pallets, admit or exclude the wind from the pipes. See ORGAN.

KEY-STONE of an arch or vault; that placed at the top or vertex of an arch, to bind the two sweeps together. This, in the Tuscan and Doric orders, is only a plain stone, projecting a little; in the Ionic, it is cut and waved somewhat like consoles; and, in the Corinthian and Composite orders, it is a console, enriched with sculpture.

KIDNEY; one of the abdominal viscera, consisting of two voluminous glands, the office of which is to secrete the urine from the blood. One of these glands lies on the right, and the other on the left, of the vertebral column (or back bone). They are both contained in a fatty, cellular substance (suet), and are situated behind the *peritonæum*, and before the diaphragm and the *quadratus lumborum*. They are penetrated with blood-vessels and nerves, are of a reddish colour, and more consistent than the other glands. An external cellular membrane, and an internal fibrous membrane, envelope each kidney, which is divided into the cortical substance and the tubulous substance. The former constitutes the exterior part of the kidney, and extends between the cones formed by the latter: it secretes the urine, that is, separates its elements from the blood, and combines them; while the latter pours it into the pelvis, a membranous bag situated at the middle of the kidney, from which it is conveyed by the ureter, a membranous tube, into the bladder. The kidneys are not mere filters or sieves, as was anciently supposed, and as some modern physiologists have maintained; they are true glands, that is, a vascular nervous apparatus, having a particular action for the production of a peculiar fluid. The kidneys are subject to an inflammation, called *nephritis*, and to a nervous pain, called *nephralgia*. The centre of the kidney sometimes contains stones, gravel, or sand, which are also found in the cortical and tubulous substances adjoining, and occasion the most excruciating pain. Diseases of the kidneys are generally occasioned by excess in eating and drinking, or violent riding, or much walking. Temperance, vegetable diet, warm bathing, &c., are preventives.

KING AT ARMS, in *heraldry*; an officer, formerly of great authority, whose business is to direct the heralds, preside at their chapters, and have the jurisdiction of armoury. The origin of the title is doubtful.

KNEE, in *anatomy*; the hinge-joint which unites the *os femoris* with the *tibia*.

KNEE, in *naval architecture*; a crooked piece of timber, having two branches or arms, and generally used to connect the beams of a ship with her sides or timbers. The branches of the knees form an angle of greater or smaller extent, according to the mutual situation of the pieces which they are designed to unite. One branch is securely bolted to one of the deck-beams, and the other in the same manner strongly attached to a corresponding timber in the ship's side. By connecting the beams and timbers into one compact frame, they contribute greatly to the strength and solidity of the ship, and enable her to resist the effects of a turbulent sea. In fixing these pieces, it is occasionally necessary to give an oblique direction to the vertical or side branch, in order to avoid the range of an adjacent gun-port, or because the knee may be so shaped as to require this disposition, it being sometimes difficult to procure so great a variety of knees as may be necessary in the construction of a number of ships of war.

KNIGHT, in *chess*. The move of this piece has given rise to an interesting problem, in regard to the various modes by which the chess-board may be covered by the knight. The path of the knight over the board is of two kinds, terminable and interminable. It is interminable whenever the concluding move of a series is made in a square which lies within reach by the knight of that from which he originally set out, and is terminable in every other instance. Euler, in the Memoirs of the Academy of

Berlin, for 1759, has given a method of filling up all the squares setting out from one of the corners. He has likewise given an interminable route, and has explained the method by which the routes may be varied, so as to end upon any square. Solutions of the same problem have also been given by Montmort, Demoivre, and Mairan.

LA, in *music;* the syllable by which Guido denotes the last sound of each hexachord. If it begins in C, it answers to our A; if in G, to E; and, if in F, to D.

Laboratory; a place fitted up for the researches of the chemist. It bears the same relation to the science of chemistry as an observatory does to that of astronomy. Although the simple observation of nature is sufficient to teach us the properties of numerous compounds, and to enable us to develope, in part, those forces which produce chemical changes, still the science of chemistry must ever have remained exceedingly defective in facts, and faulty in theory, but for the light derived from experiment. It is by means of artificial fixtures and processes that the chemist obtains the elements in a state of freedom, and recombines them so as to produce, in many instances, not only their original compounds, but such as are altogether new. It is no exaggeration to say that nine-tenths of the facts of the science, and a majority of the arts depending upon it, have been derived from the laboratory. The constructions which first received this name consisted of under-ground apartments, secluded from light and the wholesome air of day—a situation it is impossible to account for, except upon the supposition that it was copied from the alchemists, who are known to have preferred such places for the purpose of secrecy. The inconveniences attending these situations, from the want of light and facilities for ventilation, as well as from the prevalence of moisture, caused them gradually to be exchanged for apartments above ground; and although, for a time, an unnecessarily gloomy and mysterious aspect was imparted to them, from their being built of stone or brick, and but imperfectly lighted, they have at length come to resemble, in their general appearance, other structures intended for the cultivation of science.

A building devoted to this purpose in connection with a scientific institution may now be described. It should be but one story in height, in order to facilitate access to the apartments, and to render more easy the bringing in of heavy articles, as wood, water, coals, and carboys, and, at the same time, to allow of openings in the roof for sky-lights and for ventilation. In some laboratories, the theatre and working-room are united in the same apartment; in others, they are separated by a partition. The advantage of the former construction is, that the furnace operations before a class are rendered more easy; but the disadvantages are, that the size of the room renders it an inconvenient place for private researches, especially in the winter, and the seats are continually subjected to the dust and litter of ordinary operations. We shall therefore treat of a laboratory in which these apartments are distinct.

The building may vary in length from fifty to eighty feet, and in breadth from twenty-five to fifty feet. It should be well pierced with windows laterally, and also with sky-lights and openings in the roof. The lecture-room should occupy two-thirds of the length of the building; and the partition which separates it from the working-room and other apartments must contain the flues that are requisite for the furnaces of the whole establishment: these may be spread over the wall on both sides, and finally be carried out of the roof in one general chimney. The floor, from eight to twelve feet in advance of this wall, should be paved with stone, or brick; in front of which, and immediately before the seats for the class, a table, with occasional breaks for passages, gasometers, and a pneumatic cistern, should extend quite across the room, from side to side. At the two extreme ends of the table, cupboards should be erected against the wall, with glass doors, for the reception of the jars of the pneumatic cistern, measures, retorts, flasks, receivers, and the bottles and vials containing the chemicals employed for demonstration. The table should be abundantly provided with drawers of different sizes, in some places extending quite down to the floor, for the reception of substances employed in a course of demonstrations, and which it is not necessary to keep in vials and bottles, such as the common metals and many earthy and metallic salts; they are also required for the numerous tools, knives, files, gimlets, forceps, and other indispensable articles, as corks, valves or glass plates, stirrers, strings, bladders, tow, matches, sand, tapers, glass, metallic, and earthen tubes, stop-cocks, &c.

Two or three portable furnaces, of different sizes and shapes, may have a place near the wall for ordinary furnace operations; and a recess in the wall, centrally placed, and about four feet from the floor (similar in shape to a common fire-place), should be provided, with a strong draft, for those experiments which are attended with dangerous exhalations.

The seats may be arranged as is usual in other lecture-rooms. The floor room upon the other side of the partition may be divided, lengthwise of the building, into two apartments, separated by a narrow space-way, one of the rooms having double the dimensions of the other; the larger being the working-room; the smaller, an apartment for receiving delicate articles of apparatus, as balances, electrical machines, air-pump, &c., and which would be liable to injury if exposed to the attacks of the damp and corrosive vapours that are continually floating about in the other rooms. The entry should communicate with the theatre by a door: a double door, also, connecting the working-room and the lecture-room. The whole floor of the working-room is best paved with brick or stone.

The first fixture of importance in this room is the general working furnace. Its use is partly domestic, partly chemical; for it is intended to warm and air the place, occasionally to heat water, as well as to supply the means of raising a crucible to ignition, or of affording a high temperature to flasks and evaporating basins, through the agency of a sand-bath. It should be built with a table top. The fire-place itself should be constructed of brick-work, with iron front and fittings; and the flue, being carried horizontally for three or four feet, may afterwards be carried off to, and connected with, the main flue existing in the wall. The fire-place and horizonal flue should be covered with a large plate of cast iron, of from two to three feet in width, which may be formed, in the middle, over the heated part, into sand-baths; a round movable one over the fire itself, and a long fixed one over the flue. The sand-baths supply every gradation of heat, from dull redness, if required, down to a temperature of 100° or lower, whilst on each side of them exists a

level surface, which answers every purpose of an ordinary table, and supplies extraordinary facilities to experiments going on in the sand-bath or furnace. This furnace may be advantageously placed directly against the wall which separates the working-room from the theatre. A large, projecting, wooden hood should be suspended over the sand-bath, to receive the fumes evolved during the digestions and solutions made upon it, and to conduct them away into the chimney. (For a particular description of this furnace, see Faraday *On Chemical Manipulations*.) Close by may be placed another furnace for heating a large copper boiler, intended to supply the laboratory with hot water; the boiler should also be fitted with a head, worm, and refrigerator, in order to provide an occasional supply of distilled water. The tables should be as extensive as the room will allow, and be so placed as to admit of ready access; hence a large one, placed towards the middle of the room, and in such a situation as to be well lighted, is very useful. It should be made strong, and furnished with drawers, unless it be closed in with doors, so as to form cupboards. To protect it from corrosive fluids, as acids and alkalies, it should be covered with sheet lead. In a corner, and as much out of the way as possible, a sink of stone, or of strong woodwork lined with lead, must be provided. It must be supplied with water, if possible, from a cistern or aqueduct, since an unlimited supply of water is demanded in a laboratory. A place in its immediate neighbourhood is to be appropriated to the cleansing accompaniments of a sink, such as pails, pans, sponges, brooms, brushes, &c.

Between the table and the working furnace may be placed the pneumatic cistern, which should be of larger dimensions than that employed in the theatre. If the surface of water be nineteen inches by twenty-eight, and a well be formed at one end of fourteen inches by ten, and twelve inches in depth, so as to leave a continuation of shelf surface, on three sides of the well, of two inches and a half in width, it will be found sufficiently large for almost any purpose. It should have shelf room sufficient to hold several jars of gas at once. It should be filled with water until it is an inch and a quarter or an inch and a half above the shelf, and should be provided with a stop-cock, by which the water may be drawn off when it has become acidified or dirty. Such a trough is best made of japanned copper, and supported in a wooden frame, so as to stand about thirty-nine inches from the floor; or it may be made of wood, and lined with sheet lead. Unless the establishment is very extensive, one mercurial cistern will answer for both rooms; it may be shaped out of marble or soap-stone, or be made of cast iron, and mounted upon a firm frame fitted with rollers. Cupboards are very useful; and at least two large ones, with shelves, ought to be provided, in order to preserve chemical preparations, and the neater sort of apparatus, from the dust and dirt which are constantly moving and settling in the laboratory. All parts of the walls within reach should be fitted up with shelves, in a firm manner, to receive bottles and jars; also a tube-rack should be provided, to hold pieces of glass tube, from one to three feet long. A part of the wall should be furnished with long spikes, to hold retort and flask rings, large bent tubes, siphons, coils of wire, iron tongs for holding flasks, &c.

Among other indispensable furniture may be enumerated the following articles: one or two large wooden blocks, to serve as bases on which to put heavy mortars; an anvil, or spike, with its foot-block; a vice affixed to a side table; hammers; cold chisels; a screw-driver; saws; cutting chisels; gimlets; brad-awls; half-round, flat, and small three-square files; forceps; a trowel; a soldering-iron, with its appendages; a glue pot; nails; screws; spatulas of silver, ivory, steel, and wood; corkscrew; shears; blow-pipes; scratching diamond, &c. A number of filtering stands, supports for retorts and flasks, and wooden forms for holding glass evaporating basins, flasks, and receivers, should be provided; also a great variety of common, kitchen, open furnaces. The cellar beneath the working-room should contain the more bulky articles, and such as do not receive injury from a slight degree of moisture, as lute-sand, charcoal, bricks, carboys of acid, voltaic troughs, &c. Doctor Henry recommends that the painting of that part of the laboratory furniture which is exposed to the action of acids be done with the sulphate of lead.

Laboratory, in *military affairs*, signifies that place where all sorts of fireworks are prepared, both for actual service and for experiments, viz. quick-matches, fuzes, port-fire, grape-shot, case-shot, carcasses and grenades, cartridges, shells filled, and fuzes fixed, wads, &c., &c.

LABOUR, in *physiology*, is the act by which a female of the genus *mammalia* brings one of her own species into the world. When the fœtus has remained its due time in the womb, and is in a condition to carry on a separate existence, it is extruded from its place of confinement, in order to live the life which belongs to its species, independently of the mother. The womb having reached its maximum of growth, with the increasing size of the fœtus, its peculiar irritability excites in it the power of contraction; it thereby narrows the space within, and pushes out the mature fœtus. The period of gestation is very different in different animals, but, in each particular species, it is fixed with much precision.

In the womb, the corporeal frame of man commences existence as an embryo, after further developement appears as a fœtus, then as an immature, and finally a mature child. With its growth and increasing size, the membranes which envelope it enlarge, the womb also expanding to give room for it. At the end of the thirty-ninth or the beginning of the fortieth week, the child has reached its perfect state, and is capable of living separate from the mother; hence follows, in course, its separation from her, i. e. the *birth*. Contractions of the womb gradually come on, which are called, from the painful sensations accompanying them, *labour-pains*. These are of two kinds: first, the preliminary pangs, which begin the labour, do not last long, are not violent, and produce the feeling of a disagreeable straining or pressure. When the pregnant female is attacked by these, she is often unable to move from her place till the pang is over, after which she may be free from pain for some hours. Then follow the true labour-pains; these always last longer, return sooner, and are more violent. The contractions of the womb take place in the same order as the enlargement had previously done, the upper part of it first contracting, while the mouth of the womb enlarges, and grows thin, and the vagina becomes loose and distensible. By this means the fœtus, as the space

within the womb is gradually narrowed, descends with a turning motion towards the opening; the fluid contained in the membranes enveloping the fœtus, as the part making the greatest resistance, is forced out, and forms a bladder, which contributes much to the gradual enlargement of the opening of the womb. It is therefore injurious to the delivery if hasty or ignorant midwives break the membranes too soon. By repeated and violent throes, the membranes at length burst, and discharge their contents, and, some time after, the head of the child appears. As the skull-bones have not yet acquired their perfect form and substance, but are attached at the crown of the head only by a strong membrane, and may be brought nearer together, the head, by the pressure which it undergoes, may be somewhat diminished in size, and squeezed into a more oblong form, so as to pass through the opening of the matrix and the pelvis, in which it is contained, and, finally, through the external parts of generation; and, when this is done, the rest of the body soon follows. The act of birth or delivery is accordingly, in general, not an unnatural, dangerous, and diseased state of the system, as many timid females imagine. It is a natural process of developement, which is no more a disease than the cutting of the teeth, or the coming on of puberty, although, like them, it may give rise to important changes in the body, and to various diseases. It is true that the process of child-birth requires a violent exertion of nature, but this is facilitated by many preparatives and helps adapted to the purpose.

If the birth succeeds in the way described, it is called a *natural birth*. For this, it is requisite that the pelvis should be properly formed, and that the opening should permit a free passage to the perfect fœtus; that the growth and the size of the fœtus should be proportioned to the pelvis, especially that the head should have the size designed by nature, proportioned to the diameter of the pelvis; also, that there should be a proper situation of the womb, in regard to the axis of the pelvis, and a proper position of the fœtus, namely, the head down, the back of the head in front, and towards the opening of the womb, so as to appear first at birth; and, finally, that the external parts of generation should be in a natural state.

An easy birth takes place without any excessive strainings, and in due season. A difficult birth proceeds naturally, but is joined with great efforts and pangs, and occupies a long time—over six or eight hours. The cause of it is sometimes the stiffness of the fibres of the mother, her advanced years, the disproportionate size of the child's head, or malformation in the parent. Nature, however, finishes even these births; and women in labour ought not to be immediately dejected and impatient, on account of these difficulties. An *unnatural* (or properly an *irregular*) birth is one in which one or more of the above-mentioned requisites to a natural birth are wanting. An *artificial* birth is that which is accomplished by the help of art, with instruments, or the hands of the midwife.

Premature birth is one which happens some weeks before the usual time, namely, after the seventh and before the end of the ninth month. Though nature has assigned the period of forty weeks for the full maturing of the fœtus, it sometimes attains, some weeks before this period has elapsed, such a growth that it may be preserved alive. That it has not reached its mature state is determined by various indications. Such a child, for instance, does not cry like full-grown infants, but only utters a faint sound, sleeps constantly, and must be kept constantly warm, otherwise its hands and feet immediately become chilled. Besides this, in a premature child—more or less, according as it is more or less premature—the skin over the whole body is red, often, indeed, blue, covered with a fine, long, woolly hair, especially on the sides of the face and on the back; the fontanel of the head is large; the skull-bones are easily moved; the face looks old and wrinkled; the eyes are generally closed; the nails on the fingers and toes tender, soft, and short—hardly a line in length; the weight of such a child is under six, often under five pounds. The birth is called *untimely* when the fœtus is separated from the womb before the seventh month. Such children can rarely be kept alive; there are instances, however, of five months' children living. A curious remark is made by some writers, that a seven months' child is more likely to live than one born a month later. *Late* birth is a birth after the usual period of forty weeks. As this reckoning of the time from pregnancy to birth is founded, for the most part, solely on the evidence of the mother, there is much room for mistake or deception. The question is one of much interest in medical jurisprudence, as the enquiry often arises whether a child, born more than forty weeks after the death of the reputed father, is to be considered legitimate or not. The importance of the question, and the uncertainty of the proof, have occasioned a great variety of opinions among medical writers. Most of them doubt the truth of the mother's assertions about such a delayed birth, and give as their reason that nature confines herself to the fixed period of pregnancy; that grief, sickness, &c., cannot hinder the growth of the fœtus, &c. Others maintain, on the contrary, that nature binds herself to no fixed rules; that various causes may delay the growth of the child, &c. Abortion and miscarriage take place when a fœtus is brought forth so immature that it cannot live. They happen from the beginning of pregnancy to the seventh month, but most frequently in the third month. The occasions, especially in those of a susceptible or sanguine temperament, are violent shocks of body or mind by blows, falling, dancing, cramp, passion, &c.

LABOUR AND LABOURERS. The two great sources of income, in all communities, are labour and capital. The means of production are the land, utensils, stock, and all which constitutes capital, and the labourers who use this capital. In this general division of the means of production, the term *labour* is used in its broadest sense; for the labour of the mind, or that of the artist, which depends more upon skill than muscular exertion, is to be included in the general estimate of the productive power, if a price or market value is put upon its products in the general estimate. Nor should we, in estimating the general productive capacity, confine ourselves to the species of labour which results in the production of articles of necessity or convenience merely; since, in the products consumed by any community, it is not practicable to draw a distinction between articles of mere utility and those of taste, utility and luxury being combined in a great part of the things used or consumed by a people, whatever may be its stage of civilization and refinement. The land, and the greater part of the utensils of production, are estimated, it is true, in a great degree, and in many instances

wholly, by their mere utility for production. But it is otherwise with respect to the products intended not merely as the means of producing others, but as ultimate objects of use or consumption. Dwellings, furniture, clothing, food, all combine, in different degrees and proportions, both luxury and utility.

The quantity of wool and cotton worn and used by two persons in different ranks of life, and of different means of consumption, may be the same, and answer equally well as a protection of the person against the climate; and yet that used by one, owing to the better quality of the material, and the greater labour bestowed in fabricating it, may cost three or ten times as much as that used by the other; and yet something is paid to taste and luxury even by this latter.

The abstract utility of any article is of difficult estimation, and, though it is a proper subject of enquiry and speculation, still, in estimating the productive power of labour, in comparison with capital, the more practical rule seems to be, to take the estimate put upon it by the community itself. If, for instance, the labour of a sculptor is, in the estimation of a community, worth that of twenty day-labourers, the distribution of the annual products of the labour and capital of that community will be governed by this rule of comparison, and the sculptor will be able to consume as much in value as the twenty common labourers. Hence the proportion of the income of labour and capital will vary in different communities, according to the different arts or kinds of production encouraged. To take the same examples, though the labour of a sculptor may be equal in value, as estimated by a community, to that of twenty labourers—and the same may be equally true of the painter—yet the capital or stock required for each of these twenty labourers may be (and, if they are employed in agriculture, will be) greater than is required for either of those artists. The proportion, then, of the value of the whole capital of a community to that of the whole estimated annual value of the labour of all sorts, performed by its members, will depend upon the kind of arts pursued, so that the proportions will not be uniform in different communities. The estimated annual market value of the labour will, however, in any community, be greater in proportion to its capital than it would at first view appear to be. It has been estimated to be nearly one-fifth, exceeding or falling short of that ratio according to the circumstances and pursuits of a community; that is, supposing the capital to be stationary, the value of the whole capital, including lands, buildings, animals, furniture, utensils, and every vendible thing whatsoever, is consumed and reproduced every five years. It is evident, then, what a rapid change may be made in the wealth of a community, either for the better or the worse, by an impulse or check to its industry, or a general tendency to economy or prodigality in consumption.

The arts and employments and habits of a people are every thing in respect to their prosperity; and the actual amount of their present capital is of less importance, since, if it be too small, that is, if the people are in want of a sufficient stock to employ themselves to the greatest advantage, industry and economy may very soon supply the deficiency. The aggregate annual products of the same labour and capital are greater in one country than another. This is a distinction of great importance, which is overlooked in some economical speculations, or which, at least, has not always its just weight. The fact is, perhaps, too obvious to need proof or illustration, If, for instance, the people of one country have better lands, domestic animals, roads, utensils, or are more skilful and ingenious than those of another, the same amount of manual labour bestowed upon corresponding materials, with corresponding instruments of production, will produce greater results. The wages of labour, and the interest of money, may both, therefore, be higher in one country than in another. It does not follow, then, that, if the condition of the mere labourer be better in one country than in another, that of the capitalist will necessarily be worse. To ascertain the condition of these two classes, possessing the productive capacity and means of a community, we first enquire into the aggregate productiveness of capital and industry, and next into the distribution of the aggregate products between the two classes. And, in examining into the condition of the members of a community, the next enquiry relates to the proportionate share of each industrious class in the whole portion of the aggregate products allotted to industry, as distinguished from that which is allotted to capital. This distribution among the labouring classes themselves of the products of their labour will, of course, depend upon the estimation in which the various kinds of labour are held; and its effect on their condition will also depend very materially upon the arrangements, improvements, and facilities possessed by the community, to render their labour effective; for the compensation to labourers, individually, may be small, and yet the expense of the whole class of the community to which they belong very great. To take a familiar instance, if, from the thinness of the population, or other causes, the receivers and distributors of the articles of production and consumption among the people, that is, the retail dealers, can transact but a small amount of business each, though the earnings of each one may be small, their aggregate compensation must be large.

In countries half civilized, and in which the arrangements and facilities for exchange are rude and imperfect, the usual profits of trade are at an enormous rate per cent.; and yet the wealth of these traders will be very trifling, in comparison with that of the merchants and traders of a more civilized, improved, and populous community, though the per centage of profit of these latter may be much lower. The same distinction will hold good in respect to every other pursuit and employment in a community: the proportion of the whole products awarded to any one class may not correspond at all to the individual advantage or disadvantage of the members of that class, in their pursuits, in comparison with that of those of any other class. The compensation of any one class of a community, in comparison to any other, will evidently depend upon the course taken by the taste and luxury of the community; for we may assume it as a general doctrine, that when the taste and passions of a community lead to a large consumption of the articles produced by any class, or if the services of its members are considered particularly beneficial, these members will be liberally compensated. If, for instance, as is, or at least has been, the fact in some countries, the inhabitants suppose that their future welfare does not depend so much upon their own characters and conduct as upon the prayers and good offices of their spiritual guides,

they will deem it impossible to reward these spiritual guides too liberally, seeing they have the salvation of the rest at their disposal. The same principle will hold true in respect to any other class: in proportion as its employment goes along with the tastes and passions of the community will its members be rewarded for their labours. The effect will not however necessarily extend itself to all the members of the class.

Suppose, for example, that the taste and vanity of a people appear very much in their apparel and personal ornaments: it will not follow that all clothmakers, tailors, jewellers, hatters, and shoemakers will have the highest wages in the community; but the result will be that a high price will be paid for excellence of material or superiority of skill in the manufacture of those articles. The moment, therefore, in which civilization commences—and some degree of it is co-eval with the existence of every society—excellence in some arts or employments will meet with extraordinary rewards. As arts and civilization advance, the objects of fashion and taste will be multiplied, and with them the kinds and varieties of excellence of materials or skill which will be esteemed of extraordinary value. The effect necessarily is to produce a comparative depression in the value of all ordinary products and unskilful labour. Accordingly, the ordinary labourers, in all the arts, become by degrees a distinct class. In a refined community, abounding in arts, this class necessarily becomes numerous, and the condition of its members is a subject of solicitude to the philanthropist, and of interest to the economist and statesman. The security and welfare of the whole community will depend very materially upon the character and condition of this part of the population. The greater the distance between this class and the rest—the more effectually they are set off from the others—the more unnatural and distorted will be the state of society, and the more frequent will be scenes of disorder and vice. It is one of the first and most important maxims of policy and economy, then, to sustain the members of this class, not by giving them the control and management of affairs, for which of course they are not the best fitted,—but by using all possible means, whether by legislation or social influence, to give them education, good habits, and good morals, to inspire and maintain in them a respect for themselves, and secure to them the respect of others.

Labour-saving Machines. Montesquieu somewhere regrets the introduction of water-mills for grinding corn, instead of the hand-mills formerly in use, as it threw a great many labourers out of employment, besides diverting the water from the purposes of irrigation. Upon this principle of throwing labourers out of employment, the English weavers were opposed to the use of power-looms. It is not remarkable that labourers themselves, who, for a time, feel the inconveniences of the introduction of any improvement, should oppose its introduction; but it is singular that any man of enlarged and philosophical views should fall into such a notion. Nobody certainly would think it a misfortune to a community that, in consequence of some improvement in agriculture, the same labour would produce a greater quantity of grain; on the contrary, every one consents to the praise bestowed by Johnson upon the man who makes two blades of grass grow where only one grew before. And an improvement in machinery, whereby the same labour will produce twice the quantity of cloth, is precisely the same in its general effects upon the condition of the community as an improvement in agriculture. But, in a case of improvement in machinery, the effect is more apparent and more sudden, as it will spread rapidly, and accordingly the inconvenience to the labourers is in fact greater, though it can last only for a time. However, the circumstance that its effect in discharging labourers is only temporary, though it shows that the inconvenience to the community is very limited, while its advantages are permanent, yet affords no great consolation to the labourers themselves, if the population is dense and employment difficult to be obtained, since, while this temporary effect is passing off, they may starve. To avoid producing distress and consequent disorder, labour-saving machinery, therefore, should be introduced gradually among a community of labourers, like those of this country, to whom it is ordinarily difficult to find full employment, and who, if unemployed, are immediately reduced to distress.

Labyrinth, with the ancients, a building containing such a number of chambers and galleries, one running into the other, as to make it very difficult for a stranger to find his way through it. The Egyptian labyrinth, the most celebrated of all, was situated in Central Egypt, above Lake Mœris, not far from Crocodilopolis, in the country now called *Fejoom*. According to some writers, it was built by the Dodecarchs (650 B. C.); according to others, by Psammetichus, or by Ismandes, who is also said to have been buried there. In all probability, it was a sepulchre. The building, half above and half below the ground, was one of the finest in the world, and is reported to have contained 3000 rooms, the arrangement of which seems to have been symbolic of the zodiac and solar system. All these rooms were encircled by a common wall and by columns; but the passages were so intricate that no stranger could find the way without a guide. It is said that, in the lower rooms, the coffins of the builders of this immense fabric, and of the sacred crocodiles, were deposited, and that the upper rooms excelled, in splendour and art, all human works. At present, only 150 rooms are reported to be accessible: the others are dark, and choked with rubbish. Respecting the interior construction and the destination of the labyrinth of Crete we know still less. The ancient writers consider this subterranean cavern to have been built by Dædalus, in imitation of that of Egypt, but on a smaller scale, by order of Minos, who confined there the Minotaur. According to others, it was a temple of the latter. The labyrinth at Clusium was erected by king Porsenna, probably for his own sepulchre. It was a square building of stone, fifty feet in height and thirty on each side. At each corner stood a pyramid, and also one in the centre, each 150 feet high, and at the base 75 feet wide. These edifices were not built for the purpose of making people lose their way; this was merely an accidental peculiarity, on account of which every confused mass of things, difficult to be disentangled, has been called a *labyrinth*.

Lac, Lak, Laak, and Lak'h, are different ways of spelling the vulgar derivatives from the Sanscrit words *lákshà* and *laksha*, i. e. one hundred thousand; a name given by the Hindoos to the *coccus lacca* and *gum-lac*, for which they have six different terms. The gum-lac is probably discharged by the coccus,

as a defence for its eggs, which are deposited on the bihar tree. Four kinds are known—stick-lac, seed-lac, lump-lac, and shell-lac. The first is the gum before its separation from the twigs which it incrusts; and the best is of a red purplish colour: the second is the gum in a granulated form, stripped from the twigs, and perhaps boiled, by which a portion of the colour is lost: the third is the seed-lac, melted into cakes: and the fourth, the common form in which it is known in Europe, is the purified gum: the best is amber-coloured and transparent. In the East it is much used for trinkets. It is the basis of the best sealing-wax. It forms varnishes, furnishes a brilliant red dye, and, mixed with thrice its weight of fine sand, is made into polishing stones.

Lac, in its original meaning, is applied to the computation of money in the East Indies. Thus a *lac* of rupees is 100,000, which, supposing them to be *sicca* or standard, are equal to 12,500*l*.

Lace is a species of net-work, made of silk, thread, or cotton, upon which, in old times, patterns were embroidered by the needle, after its construction: they are now, for the most part, formed during the knitting itself. The best laces are made at Mechlin, Brussels, Antwerp, Ghent, and Valenciennes. Lace made by machinery is largely manufactured at Nottingham.

The invention of lace-knitting is attributed by Beckmann to Barbara, wife of Christopher Uttman of St. Annaberg, in 1561. Paulus Jenisius, in his history of that town, states as follows: *Hoc anno* (1561) *filum album retortum in varias formas Phrygio opere duci cœpit;* and there are many other authorities for the name of the workwoman. It may be, however, that she introduced the manufacture, rather than invented it. Lace worked by the needle is of far older date. It is found richly and abundantly in church furniture of great antiquity, and is supposed to have been originally made in Italy, particularly at Genoa and Venice. The *Opus Phrygianum*, to which allusions are made by Plautus and Pliny is considered by Beckmann to have been no more than needle-work; and so the expressions of the latter writer are understood by Holland: "As for embroderie itself, and needle-worke, it was the Phrygians' invention, and hereupon embroderers in Latine bee called *Phrygiones*." *Point-lace* is that embroidered by the needle, and, from the great labour required, is therefore most expensive. In the lace knit by hand, as many threads are employed as the pattern and breadth require. These are wound upon the requisite number of bobbins (made of bone, whence the name *bone-lace*), which are thrown over and under each other in various ways, so that the threads twine round pins stuck in the holes of the pattern (a stiff parchment stretched on a cushion or pillow), and by these means produce the openings which give the desired figure. In that made by machinery, the meshes are all formed by a continuation of a single thread. The coarsest is called *Mechlin-net*, the finest *bobbin-net*, from the employment of bobbins. Lace made by the loom is generally known as *British* lace.

Mr. Babbage gives the following curious account of lace made by the *phælena pardilla* or caterpillar. It was contrived by a gentleman of Munich. He makes a paste of the leaves of the plant which is the usual food of the species of caterpillar he employs, and spreads it thinly over a stone or other flat substance. He then, with a camel-hair pencil dipped in olive oil, draws upon the coating of paste the pattern he wishes the insects to leave open. This stone is then placed in an inclined position, and a number of caterpillars are placed at the bottom. A peculiar species is chosen, which spins a strong web; and the animals, commencing at the bottom, eat and spin their way up to the top, carefully avoiding every part touched by the oil, but devouring all the rest of the paste. The extreme lightness of these veils, combined with some strength, is truly surprising. One of them, measuring twenty-six inches and a half by seventeen inches, weighed only 1.51 grain, a degree of lightness which will appear more strongly by contrast with other fabrics. One square yard of the substance of which these veils are made weighs $4\frac{1}{3}$ grains, whilst one square yard of silk gauze weighs 137 grains, and one square yard of the finest patent net weighs $262\frac{1}{2}$ grains. The ladies' coloured muslin dresses mentioned in the table subjoined cost ten shillings per dress, and each weighs six ounces; the cotton from which they are made weighing nearly six ounces and two-ninths, avoirdupois weight.

Weight of one square yard of each of the following Articles.

DESCRIPTION OF GOODS.	Value per yard measure.	Weight finished of one square yard.	Weight of cotton used in making one square yard.
	s. d.	Troy Grains.	Troy Grains.
Caterpillar Veils	. . . .	$4\frac{1}{3}$	. . . .
Silk Gauze 3-4ths wide	1 0	$137\frac{1}{4}$	. . . .
Finest Patent Net	. . . .	$262\frac{1}{2}$	. . . .
Fine Cambric Muslin	. . . .	$551\frac{1}{2}$	. . . .
6-4ths Jaconet Muslin	2 0	613	670
Ladies' coloured Muslin Dresses	3 0	788	875
6-4ths Cambric	1 2	972	1069
9-8ths Calico	0 9	988	1085
½ yard Nankeen	0 8	2240	2432

Lactometer. This is an ingenious little instrument, and very valuable, as it offers a ready mode for ascertaining the quality and purity of milk. In the dairy, it likewise enables the farmer to judge of the value of his cows from the quality of the milk. From the high price at which it is vended by mathematical instrument makers, it is, however, little known, and the principle of its construction is still less appreciated. It is constructed on the principle of the separation of cream from the milk, and the means to determine the proportion; this will at once suggest its nature. Upon a graduated tube, of the length of ten inches, or any other proportion, is described a scale containing ten equal parts. The three upper divisions are again to be subdivided into ten equal parts, and we shall thus have the scale containing one hundred and numbered in thirty equal parts. To ascertain the quality of any sample, it is only necessary to fill the tube with milk to the first point; after standing three hours, the whole of the cream will separate and float to the top; the mark to which this descends will indicate the per-centage of cream, and, in consequence, the proportionate quality of the milk. Milk seldom yields above twenty-five per cent. of cream;—that vended in the metropolis rarely affords more than seven.

Lamp. The invention of lamps is ascribed to the Egyptians. At the festivals in honour of Minerva, at Sais in Lower Egypt, great numbers of lamps

were kept burning. They were known even in the times of Moses and Job. The Egyptians were also the first who placed burning lamps in the tombs with their dead, as an emblem of the immortality of the soul. From Egypt, the use of lamps was carried to Greece, where they were also consecrated to Minerva, the goddess of learning, as indicative of the nightly studies of the scholar. From Greece, the use of lamps passed to the Romans. The first person who is known to have published a collection of ancient lamps is Fortunio Liceto, an Italian, whose chief design appears to have been to prove the possibility of the existence of inextinguishable, or rather perpetually-burning, lamps. Pietro Santo Bartoli, a countryman of his, afterwards published at Rome, in the year 1691, the collection of Bellori; but these engravings are exceedingly ill executed and unfaithful. Passeri, however, another Italian, published, at the suggestion of the academy of Pesaro, a collection of 322 lamps, which he possessed in his museum. The above-mentioned collections, however, have been much surpassed in beauty and interest by that of Portici. The sixth hall of that museum is entirely filled with lamps and candelabras discovered in the houses of Pompeii and Herculaneum. Representations of these were published in 1792, in ninety-three copper-plates, exclusive of vignettes. They form the ninth volume of the *Antiquities of Herculaneum*. We find there represented and explained upwards of 200 lamps and candelabras of bronze and terracotta.

The ancients appear to have very early acquired the practice of using lamps. The use of oil was not perhaps known to the Romans in very remote ages, although the Greeks unquestionably were acquainted with it, as appears from several passages in Herodotus. We find, indeed, the figure of the lamp sculptured and engraved on many of the most ancient Greek vases. It is with a lamp that Mercury, as depicted on one of these, lights Jupiter, who is represented scaling with a ladder the chamber of Alcmena. Baked earth was the substance of which the earliest lamps were composed, but subsequently we find them of various metals—of bronze more particularly. A few ancient lamps of iron are also extant; but these are rare, either because that metal was little used for the purpose, or on account of its more ready destruction in the ground. There are four specimens in the museum of the king of Naples, at Portici, where there is likewise one specimen of a lamp of glass. It is entirely solid, and in one single piece. Pausanias mentions a golden lamp in the temple of Minerva, and St. Augustine speaks of lamps of silver. No antique of either kind, however, has reached modern times. The testimony of Pliny, St. Augustine, and others, has led to the belief that the ancients had perpetual lamps, and Liceto composed a work to establish this supposition. Different authors mention instances of lamps which in modern times have been found burning in ancient sepulchres, but were extinguished as soon as the external air was admitted. The most famous instance is that of the tomb of Tulliola, daughter of Cicero, discovered in 1540. None of these instances, however, can be considered as proved. The idea probably arose from the inflammation of the hydrogen gas contained in these caverns, when explorers entered them with torches.

The lamps or candlesticks made use of by the Jews, in their own houses, were generally put into a very high stand on the ground. The lamps supposed to have been used by the foolish virgins, &c., in the gospel, were of a different kind. According to critics and antiquaries, they were a sort of torches made of iron or potter's earth, wrapped about with old linen, and moistened, from time to time, with oil. (*Matt.* xxv. 1, 2.) The lamps of Gideon's soldiers were of the same kind. The candlestick, with seven branches, placed in the sanctuary by Moses, and those which Solomon afterwards prepared for the temple, are said to have been crystal lamps filled with oil, and fixed upon the branches. Among the Romans, also, it was customary to have the lamp either depending from the ceiling or placed on a stand in the room, since the use of tables was not common to them, and their attitude, in studying, as well as at their repasts, was a half-recumbent one, holding their scroll or tablets before them on their knees. These stands were often highly ornamented. The most common form of them was a tripod with lion's feet, from which sprung sometimes the shaft of a column, according to one of the orders of architecture, the disc placed to receive the lamp forming the capital. These vessels were generally ornamented with mythological or allegorical subjects, and their shape varied greatly. Sometimes it was a simple disc with a hole in the circumference through which to pass the wick, and another in the middle to pour the oil into. At other times, they represented the appearance of a boat. Occasionally their extremity terminated in two or three divisions, according to the number of beaks; but it would be endless to attempt to pursue these details. Inscriptions were likewise often placed upon them.

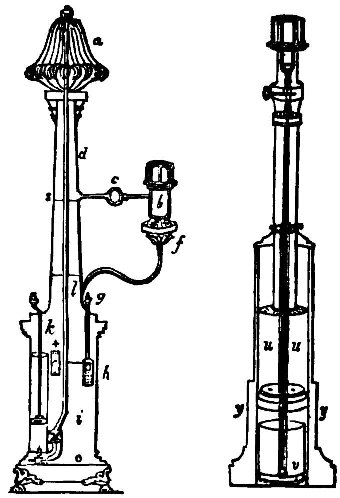
Public illuminations on occasions of national rejoicing were common to the Romans. On the birth-days of their princes, on great religious solemnities, &c., they suspended lamps at the windows. Juvenal and Persius both make mention of this usage. Various motives have been assigned for the ancient practice of placing lamps in sepulchres. One of the most ingenious, and perhaps the most satisfactory, is that it was allegorical of the cessation of mortal life—of the separation of the soul, which the ancients regarded as an emanation of fire. On some sepulchral lamps we find sculptured the figure of a butterfly, in allusion no doubt to the equally cheerful and elegant imagination of the escape of the spirit, in a more aërial semblance, from its chrysalis state. The early Christians adopted, in their monuments, this pagan usage, together with many others, and the lamp has been found in the tombs of saints and martyrs, and of distinguished men who embraced Christianity. In these instances it was no doubt meant still more to be illustrative of that divine flame by which they were inspired, and whose inward light guided them through the many savage persecutions suffered by the primitive followers of our holy faith. The shapes of ancient lamps, as well as many other ancient utensils, have been imitated with much success by Mr. Wedgwood.

The best lamps now in use are those invented by Argand, at Geneva, in 1784. The principle on which the superiority of the Argand lamp depends is the admission of a larger quantity of air to the flame than can be done in the common way. This is accomplished by making the wick of a circular form, by which means a current of air rushes through the cylinder on which it is placed with great force; and, along with

that which has access to the outside, excites the flame to such a degree that the smoke is entirely consumed. Thus both the light and heat are prodigiously increased, the combustion being exceedingly augmented by the quantity of air admitted to the flame; and what, in common lamps, is dissipated in smoke, is here converted into a brilliant flame. This lamp is now very much in use, and is applied, not only to the ordinary purposes of illumination, but also to that of a lamp-furnace for chemical operations, in which it is found to exceed every other contrivance yet invented. It consists of two parts, viz. a reservoir for the oil, and the lamp itself. The Argand burner is constructed by forming a hollow cylindrical cavity, which receives oil from the main body of the lamp, and, at the same time, transmits air through its axis, or central hollow. In this cavity is placed a circular wick, attached, at bottom, to a movable ring. This ring is capable of being elevated or depressed by means of a rack and pinion, or more commonly by a screw; so that the height of the wick may be varied to regulate the size of the flame. On the outside is placed a glass chimney, which is capable of transmitting a current of air, on the same principles as a common smoke flue. When this lamp is lighted, the combustion is vivid, and the light intense, owing to the free and rapid supply of air. The flame does not waver, and the smoke is wholly consumed. The brilliancy of the light will be still further increased if air be made to impinge laterally against the flame. This is done either by contracting the glass chimney near the blaze, so as to direct the air inwards, or by placing a metallic button over the blaze, so as to spread the internal current outward. The Argand lamps are called, in France, *lampes à Quinquet*, or, more briefly, *Quinquets*, from an artist of the name of *Quinquet*, in Paris, with whom Argand was connected. To avoid the shade occasioned in common lamps by the reservoir for the oil being under the flame, various contrivances have been introduced, in which the reservoir is placed at a distance from the flame.

In the *astral* and *sinumbral* lamps, the principle of which was invented by Count Rumford, the oil is contained in a large horizontal ring, having a burner in the centre, communicating with the ring by two or more tubes placed like rays. The ring is placed a little below the level of the flame, and from its large surface affords a supply of oil for many hours. A small aperture is left for the admission or escape of air, in the upper part of the ring. When these lamps overflow, it is usually because the ring is not kept perfectly horizontal, or else because the air-hole is obstructed—a circumstance which may even happen from filling the lamp too high with oil.

It is necessary to observe that there are two principles that govern the advantageous production of artificial light: the most material one is the proper supply of oxygen to the hydrogen and carbon of the decomposed fuel; the other to keep up a flow of oil as near the flame as possible, to prevent the wick being incrusted by the gluten of which oils are in part composed. These two principles must be considered essential in the formation of a lamp; and, therefore, cannot be departed from, without occasioning a waste of fuel. The lamps now to be described, which are a late invention, are intended to bring these principles into action. The air is regulated, in its passage to the wick, so that the flame may be supplied in proportion to its bulk, and also that the inner and outer currents of air acting on the Argand burner may be so proportioned that the flame may itself become a perfect cylinder. In these lamps the oil is always kept in close contact with the flame, and is so abundant that a part of it is even allowed to pass over the mouth of the burner, to the reservoir. By a contrivance which will be understood on a reference to the engravings, this oil is returned to the wick for combustion.



The first of these, or right-hand figure, is called a pressure lamp, the oil being forced up to the burner by a movable weight, which is required rather to overbalance the column of oil when it extends to the full height of the burner. The weight *v* is attached to a circular disc. This disc is surrounded with a leather packing, which works close to the sides of the cylinder *u u*. The passage of the oil is thus confined to the pipe which leads to the burner, over which the disc and the weight work. In the construction of this lamp there are three pipes; the centre pipe conveys the oil from under the weight to the burner; the one over that brings the oil not consumed by the wick to the top of the disc, that it may again pass under the weight; the third, or outer pipe, gives the power of raising the weight, to put it again in action, after it had pressed all the oil from under it, and thus enables it to take through a valve in its centre a fresh supply. The quantity of oil forced to the burner is regulated by a key, which can be raised as required. *y y* is the ornamental case of the oil cylinder.

The left-hand figure in the diagram is called a pump-lamp, the oil being raised from the reservoir *i* in its base, through the pipe *l*, to the reservoir *a d*, by the small pump *k*. The quantity of oil supplied to the burner, *b*, is regulated by the key *c*. As it is intended that the supply of oil should exceed the consumption of the wick, means have been taken to convey the surplus through the pipe *f* to the reservoir *i*. The flooring *s* separates the upper reservoir from the lower part of the lamp. *h* is a float to show by raising the rod *g* when the lower reservoir is full; *o* is an aperture to let out the foul oil when necessary; + is an air-valve.

LAMP-BLACK. See CARBON.

LANCE; a weapon consisting of a long shaft, with a sharp point, much used, particularly before the invention of fire-arms. It was common among the Greeks and Romans. The Macedonian phalanx was armed with it, and it was the chief weapon of the Roman infantry: the javelin, or *pilum*, was but secondary. The lance is found among almost all uncivilized tribes: it was the chief weapon in the middle ages,

and is now considered one of the most effective arms of cavalry.

The lance of the knight, in the middle ages, was of a peculiar form. Near the lower end, it was very thick, with a deep opening, in which the arm was placed when the lance was put in rest, preparatory to a charge. Immediately in front of the opening, the lance was from a foot to a foot and a half in diameter, and sloped off towards the upper end, which was from half an inch to three-quarters in diameter. From this weapon the small bands, of which the cavalry of the middle ages consisted, took their name. A *lance* denoted a man at arms (horseman completely armed) with four or five attendants. Among the French, in the fifteenth century, these attendants consisted of three archers, one *coutillier* (so named from the long broad dirk in his belt), and one page or valet.

The introduction of fire-arms gradually led to the disuse of the lance in the West of Europe, though it continued among the Turks, Albanians, Tartars, Cossacks, Poles, Russians, and other Sclavonic tribes, among whom it was borne by light-armed cavalry, on fleet horses. Frederick the Great, seeing the advantageous use made of this weapon by the Poles, gave it to a portion of his cavalry, and afterwards formed an entire regiment of lancers. The Austrians followed, and soon established three regiments of *Uhlans*, as they were termed. After the partition of Poland, many Poles entered the French service, and a body of Polish lancers was established. The war with Russia, in which the efficiency of the lance in the hands of the Cossacks, particularly in 1812, was strikingly manifested, brought this weapon into still more repute, and the Prussians formed three regiments of *Uhlans*. The French lancers were formed in 1813, to cope with the Cossacks. Almost all the armies of Europe now have regiments of lancers: those of the British were found of the greatest service at the battle of Waterloo. To use the lance with effect, however, requires much practice.

The lances now in use among the European cavalry have a shaft of ash or beech wood, eight, twelve, or even sixteen feet long, with a steel point, eight or ten inches long, and, to prevent this being hewn off, the shaft is guarded by two strips of iron, a foot and a half to two feet long, below which an iron ball is sometimes placed to prevent the lance-point from penetrating too far. The other end has an iron cap, to prevent its splitting. The point has a small flag, intended by its waving to frighten the horses of the enemy. When not in use, the lance is carried in a leathern shoe, by the right stirrup, dependent by a leathern thong on the right arm. In use, it is carried under the right arm. This weapon requires a practised horseman. (See Pike.)

Land, in *nautical* language, makes part of several compound terms: thus *laying the land* denotes that motion of a ship which increases its distance from the coast, so as to make it appear lower or smaller on account of the intermediate convexity of the sea.—*Raising the land* is produced by the motion of the vessel towards it.—*Land is shut in* signifies that another part of land hinders the sight of that the ship came from.—*Land to;* or so far from shore that it can be only just discerned.—*To set the land;* that is, to see by the compass how it bears.

Land-Breeze; a current of air which, in many parts within the tropics, particularly in the West Indies, regularly sets from the land towards the sea during the night, and this even on opposite points of the coast.—*Land-locked* is said of a harbour which is environed by land on all sides, so as to exclude the prospect of the sea, unless over some intervening land.—*To make the land* is to discover it after having been out of sight of it for some time.

Land-Mark; any mountain, rock, steeple, or the like, near the sea-side, which serves to direct ships passing by how to steer, so as to avoid certain dangers, rocks, shoals, whirlpools, &c.

Landscape-Painting. See Painting.

Laniard, or Lanniers; a short piece of rope or line, fastened to several machines in a ship, and serving to secure them in a particular place, or to manage them more conveniently: such are the laniards of the gun-ports, the laniards of the buoy, the laniard of the cat-hook, &c. The principal laniards used in a ship are those employed to extend the shrouds and stays of the mast by their communication with the dead-eyes and hearts, so as to form a sort of mechanical power, resembling that of a tackle.

Lantern; a common contrivance to carry a lamp or candle in, being a kind of cover usually made of tin, with sashes of some transparent matter, as glass, horn, &c., to transmit the light. Theopompus, a Greek comic poet, and Empedocles of Agrigentum, are the first who have spoken of this kind of illumination. In the *Antiquités d'Herculaneum*, vol. vii., will be found represented a collection of ancient lanterns, one of which, of a round form, was discovered in one of the great roads of Herculaneum in 1760, and another, 1764, at Pompeii, in the vestibule of a house, by the side of a human skeleton. The use to which these instruments were put was various. A modern author has stated, without sufficient proof however, that the games of the circus, at Rome, and the sacred games in Greece, were celebrated by this kind of light. Plutarch expressly says that they were used in augury. It is more certain still that they were common among the military, and were always carried before any troops who had to march by night. These were borne upon the top of a pike, and were constructed of a fashion to throw light only behind them.

Dark Lantern; one with only a single opening, which may also be closed up when the light is to be entirely hidden, or opened when there is occasion for its assistance to discover some object.

Magic Lantern, or *laterna megalographica;* an instrument used to magnify paintings on glass, and throw their images upon a white screen, in a darkened chamber. On the fore part of the lantern there is a thick double-convex lens, or a plane-convex (usually called a *bull's eye*), of short focus. The lantern is closed on every side, so that no light can come out of it but what passes through the lens. In the direction of this lens, there is a tube fixed to the lantern, which has a lateral aperture from side to side; through this a glass slider, with small painted images, is moved in an inverted position. The fore part of the tube contains another sliding tube, which carries a double-convex lens. The effect of those parts is as follows:—The thick lens, in the side of the lantern, throws a good deal of light from the candle upon the image; and, to increase that light still more, a reflector is very often, but not always, placed in such lanterns; and, the flame being in the focus of the reflector, the light proceeds in parallel lines from the reflector to the lens. The image, being thus well

illuminated, sends forth rays from every point, which, by passing through the lens belonging to the sliding tube, are conveyed to a focus upon the wall, and form the large images.

The *Phantasmagoria* is like the magic lantern, only, instead of the figures being on transparent glass, all the glass is opaque, except the figure only, which being painted in transparent colours, the light shines through it, and no light can fall on the screen but what passes through the figure. The screen is very thin silk, between the spectators and the lantern, and, by moving the instrument backwards or forwards, the figures seem to recede or approach.

Laocoon, a priest of Neptune (according to some, of Apollo), at Troy, after the pretended retreat of the Greeks, was sacrificing a bull to Neptune, on the shore, when two enormous serpents appeared swimming from the island of Tenedos, and advanced towards the altar. The people fled; but Laocoon and his sons fell victims to the monsters. The sons were first attacked, and then the father, who attempted to defend them. Wreathing themselves round him, the serpents raised their heads high above him, while, in his agony, he endeavoured to extricate himself from their folds. They then hastened to the temple of Pallas, where, placing themselves at the foot of the goddess, they hid themselves under her shield. The people saw, in this omen, Laocoon's punishment for his impiety in having pierced with his spear the wooden horse which was consecrated to Minerva.

We allude to the above fabulous account to illustrate the design of one of the finest works of ancient art. It forms a group of superlative excellence, and may in this respect have a place with the "Punishment of Dirce," described in our article **Grouping**.

The principal figure is very properly placed in the centre, thus giving the pyramidal form to the whole group. Agony of the most intense kind is depicted in the countenance and convulsed body of Laocoon, who is attempting to untwine the serpents from his body. Their many knotted wreaths have also extended to the sons, who with uplifted hands and imploring eyes appear to solicit that aid from their parent which he is unable to afford.

The only fault of this group, as a work of art, is its complexity, the twining of the serpents prevents the eye from following the general outline of the figures, each of which would form a good subject for the artist.

Lapidary, in the preparation of gems for sculpture, an artificer who cuts precious stones. This art is of great antiquity. There are various machines employed in the cutting of precious stones, according to their quality. The diamond, which is extremely hard, is cut in a wheel of soft metal turned by a mill, with diamond dust, tempered with olive-oil, which also serves to polish it.

Lapidolite. See **Mica**.

Lapis Lazuli. This superb mineral, which has been seen regularly crystallized only in a few instances, occurs massive, of a rich azure-blue colour. It consists, by one analysis, of 46 silex, 28 lime, 14.5 alumine, 3 oxide of iron, 6.5 sulphate of lime, and 2 water; but a later and more interesting research has given 34 silex, 33 alumine, 3 sulphur, and 22 soda. The finest specimens are brought from China, Persia, and Great Bucharia. It is much esteemed for ornamental purposes, especially for inlaid work. The most splendid exhibition of this rare substance is made in the celebrated marble palace built by Catherine, at St. Petersburg, for her favourite Orlof, in which, according to Patrin, there are entire apartments inlayed with lapis lazuli. The ancients were in the habit of engraving upon it, of whose works several specimens are to be seen in the royal library at Paris. But its chief value consists in its affording the very precious pigment called *ultramarine*.

Laquering; the laying on metals coloured or transparent varnishes, to produce the appearance of a different colour in the metal, or to preserve it from rust. Thus laquered brass appears gilt, and tin is made yellow. Seed-lac is the chief composition for laquers, but turpentine makes a cheaper laquer.

Larboard; a name given by seamen to the left side of a ship, when the spectator's face is turned in the direction of the head.

Larboard-Tack is when a ship is close-hauled, with the wind blowing on her larboard side.

Lavender, a delightfully fragrant plant, native of the south of Europe, and now commonly cultivated in our gardens. All the labiate plants are aromatic and stimulating, but these properties are more powerful in this plant than in any other of the tribe, especially when it grows in a warm and sunny exposure. Indeed, in such situations, it sometimes contains one-fourth of its weight in camphor. To the abundance of this plant is attributed the superiority of the honey in certain parts of Europe. The volatile oil, distilled water, and tincture of lavender, are much employed in officinal preparations, and as perfumes. The flowers yield by far the greatest proportion of oil.

Lazaretto; a public building, hospital, or pest-house, for the reception of those afflicted with contagious distempers. It is more particularly applied to buildings in which quarantine is performed.

Lead is a metal very anciently known; it is often mentioned by Moses. Its alchemical name was *Saturnus*. It has a bluish-grey colour, and, when recently cut, a strong metallic lustre; but it soon tarnishes from exposure to the air; specific gravity, 11.358. It is soft, flexible, and inelastic. It is malleable and ductile. In tenacity, it is inferior to all ductile metals. It soils paper and the fingers, imparts a slight taste, and emits, by friction, a peculiar smell.

It is a good conductor of heat, melts at 612° Fahr., and, when cooled, slowly crystallizes in quadrangular pyramids. It is but slowly affected by the atmosphere at common temperatures; but, when maintained in a state of fusion, it absorbs oxygen rapidly, and is converted into a dull grey dross or powder. When this dross is heated to a low ignition, it becomes of a dull yellow colour, and is called *common massicot;* and, by a higher heat and longer exposure to the air, it assumes a deeper yellow, and is then called *massicot.* This is the *protoxide of lead,* and consists, in 112 parts, of 104 lead and eight oxygen. It is insoluble in water, melts on ignition, and is unchanged by heat in close vessels. When it contains about four per cent. of carbonic acid, it is called *litharge.* It unites with acids, and is the base of the salts of lead.

If the protoxide, or metallic lead, be subjected, during forty-eight hours, to the heat of a reverberatory furnace, it passes to the condition of red oxide, or what is commonly called minium, or red lead. This is regarded by Doctor Thomson as a mixture of the protoxide and deutoxide of lead. After the protoxide is separated by acetic acid, the *deutoxide,* of a dark red colour, remains. Its composition is, in 116 parts, 104 lead, 12 oxygen. The *peroxide of lead* is formed by passing chlorine gas through a solution of acetate of lead. Its colour is brown. Heated moderately, especially with the addition of sulphuric acid, it gives out oxygen, and becomes deutoxide; and at a cherry-red heat it passes to the state of the protoxide: 120 parts contain 104 of lead. Lead forms a compound with chlorine. The union is effected by exposing the metal in thin plates to the action of chlorine gas, or, more easily, by adding muriatic acid, or a solution of common salt, to the acetate or nitrate of lead dissolved in water. This *chloride* fuses at a temperature below redness, and forms, as it cools, a semi-transparent, horny mass, sometimes called *horn lead,* or *plumbum corneum.* It bears a full red heat in close vessels without subliming.

The pigment called *mineral* or patent yellow is a compound of the chloride and protoxide of lead. It is prepared for the purposes of the arts by the action of moistened sea-salt on litharge, by which means a portion of the protoxide is converted into chloride of lead. It is a paint little used, however, in consequence of the preference given to the chrome yellow. An *iodide of lead* is easily formed by mingling a solution of hydriodic acid, or hydriodate of potassa, with the acetate or nitrate of lead dissolved in water. It is of a rich yellow colour, and is deposited from boiling water on cooling in crystalline grains of a brilliant lustre. Lead combines with sulphur. The *sulphuret* may be made by simply heating lead and sulphur together, or by the action of sulphuretted hydrogen on a salt of lead. It is an abundant natural product, and is known under the name of *galena* in mineralogy.

The *phosphuret of lead* is formed by dropping phosphorus into melted lead contained in a crucible, or by heating equal parts of lead filings and phosphoric glass with one-eighth of charcoal powder. As respects the *uses* of metallic lead and the oxides, it is well known that the former is much employed in the arts, particularly for buildings and cisterns. For the first of these uses it has many advantages. It is easily worked into any shape, on account of its great softness, and is sufficiently malleable to fold two edges over each other, so as to make it water-tight, without soldering. This is a very great advantage, since, when pieces are soldered together, the expansion and contraction, by a change of temperature, soon cause a rupture. Although it is in very general use for water cisterns, pumps, and pipes for conveying water, serious objections have, from time to time, been urged against its employment for this purpose. It has been found that, in pure water, it is oxidized with considerable rapidity, carbonate of lead being formed by the action of the oxygen and carbonic acid of the air. But if the water, as is the case with the majority of springs, contains a small proportion of saline matter, especially if a sulphate is present, which never fails to precipitate lead from any of its solutions, the liability of the water to be prejudiced by the lead is very small. And, in other cases, there can be no danger in delivering water through aqueducts of lead, provided they are constantly kept full of water, so as always to exclude the air.

Great mischief has been produced by the use of lead in dairies. If the milk run into the slightest acidity, some lead will be dissolved, and injurious consequences will follow if it be taken into the stomach. In the granulation of lead for shot, a small portion of arsenic is added. The proportion is about two per cent. of the white or yellow arsenic. The compound is heated red-hot for three hours in an iron-pot, protected by a tight cover, when the contents are let fall into a reservoir of water, from a height of 10 to 150 feet, as the shot are to be coarser or finer. One part of tin and two of lead form an alloy fusible at 350° Fahr., which is used by tinmen under the name of *soft solder.* Lead also forms an imperfect alloy with copper. The metal used for common brass-cocks is an alloy of these two metals. The union of these two metals, however, is exceedingly slight; for, upon exposing the alloy to a heat no greater than that in which lead melts, the lead almost entirely runs off of itself. This process is called *eliquation.* Of the *oxides,* the mixture of the protoxide and deutoxide which forms the red-lead is of considerable importance as a pigment. Its manufacture in Germany is conducted as follows: 180lbs. of lead are calcined for eight hours upon the hearth of a cupola furnace, and constantly stirred; it is then left in the furnace for sixteen hours, and only stirred at intervals. This calcined lead, or massicot, is ground in a mill with water, washed on tables, and, being dried, is put into stone-pots, of such a size that thirty-two pounds fill them somewhat more than one quarter full. Several of these pots are laid horizontally in the colour furnace, so that the flame may go quite round them, and a piece of brick is put before the opening of each pot. A fire is kept up in this furnace for about forty-eight hours, and the matter in the pots stirred every half-hour. The process being over, the red-lead is passed through a sieve. In this operation, 100lbs. of lead generally increase ten pounds in weight. Red-lead is also made from litharge, by heating it in pots in a reverberatory furnace.

The *salts of lead* have the protoxide, as has before been remarked, for their base, and are readily distinguished by the following general characters:— 1. The salts which dissolve in water usually give colourless solutions, which have an astringent, sweetish taste; 2. placed on charcoal, they all yield, by the blow-pipe, a button of lead; 3. ferroprussiate of potash occasions in their solutions a white precipitate; 4. sulphuretted hydrogen and hydrosulphurets produce

a black precipitate; 5. a plate of zinc, a white precipitate, or metallic leaf.

Most of the acids attack lead. The sulphuric does not act upon it unless it be concentrated and boiling. Sulphurous acid gas escapes during this process, and the acid is decomposed. When the distillation is carried on to dryness, a saline white mass is produced, a small portion of which is soluble in water, and is the *sulphate of lead;* it affords crystals. The residue of the white mass is an insoluble sulphate of lead. It consists of five acid and fourteen protoxide of lead. Nitric acid acts strongly on lead. The *nitrate* solution yields by evaporation tetrahedral crystals, which are white, opaque, and of a specific gravity of four. They consist of 6.75 acid, and fourteen protoxide. A *subnitrate* may be formed by boiling in water equal weights of the nitrate and protoxide; also by boiling a solution of ten parts of the nitrate with 7.8 of metallic lead. Acetic acid dissolves lead and its oxides, though probably the access of air may be necessary to the solution of the metal itself by this acid.

White lead, or *ceruse*, is made by rolling leaden plates spirally up, so as to leave the space of about an inch between each coil, and placing them vertically in earthen pots, at the bottom of which is some good vinegar. The pots are covered and exposed for a length of time to a gentle heat in a sand-bath, or by bedding them in dung. The vapour of the vinegar, assisted by the tendency of the lead to combine with the oxygen which is present, corrodes the lead, and converts the external portion into a white substance, which comes off in flakes when the lead is uncoiled. The plates are thus treated repeatedly, until they are corroded through.

There is a new patent for the manufacture of white lead, which should here be noticed. It is proposed to take a quantity of sulphuret of lead or lead ore, say half a ton, and having broken it, by pounding or rolling, into a powder, then burn or roast it at a temperature below that which would melt the metal. After the ore has become cold, it is to be pulverised again, and reduced to the finest powder, and then well washed in water, taking off the lighter particles, which float, and pounding the coarser again, until the whole is reduced as fine as possible.

This powder is now to be dried in pans, by exposure to the air, or in a suitable stove; and, when perfectly dry, about two hundred weight of salt-petre is to be mixed with it, and the whole placed in a retort, to undergo a sort of distillation.

The retort to be employed is a cylindrical vessel of iron, lined with lead, placed erect within another as a jacket, and fastened together by flanges, forming a steam-tight joint, and leaving a space between, all round and at bottom, for the passage of steam, by which the retort is to be heated.

In this vessel, the materials above prepared are to be placed, and to be constantly agitated during the operation, by means of a perpendicular shaft with arms, which is introduced into the cylinder, and may be turned round by hand, or by any other convenient means.

Above the cylinder there is a vat, or cistern, intended to contain about two hundred weight of sulphuric acid, of a specific gravity of from 1.400 to 1.740. From this vat two pipes descend, one leading to the top of the cylinder, which admits the acid through a stop-cock, the other to the bottom, through the latter of which, by means of a force-pump, the acid is gradually injected into the cylinder at the lower part.

Steam from a boiler under considerable pressure is now admitted into the chamber surrounding the containing cylinder, for the purpose of heating the materials within. This operation is to be continued for several hours, the stirrer being continually turned, for the purpose of bringing all the particles of the material under the action of the acid and the heated vapour.

The top of the cylindrical vessel is of course to be closed, having an aperture with stuffing, through which the upper end of the spindle or shaft of the stirrer passes; but a tube is introduced into the top, for the purpose of carrying off the vapour arising within the vessel to a condenser, or into a chimney, or away into the open air, at a distance from the workmen. A hole is likewise made in the top with a stopper, by which small quantities of the material can be occasionally withdrawn, by a ladle, for the purpose of ascertaining the progress of the operation within.

The pulverised ore, having been thus operated upon for several hours, is afterwards allowed to remain in the retort for two or three days, or under some circumstances for a longer time, occasionally stirring it up, and drawing off the acid. It is then removed and washed in water in order to discharge the acid; and when this is done, and the material dried, a similar quantity of salt-petre is again mixed with it in the retort, and the operation performed in a fresh quantity of acid as before.

The material being a second time withdrawn from the retort, it is to be thoroughly washed in warm water, until every appearance of acid has become completely removed, after which, being dried, and then ground in water, in the way white lead is usually treated, it becomes fit for use.

The patentee proposes to employ sulphuric acid in the retort, but in the second operation he sometimes uses nitric acid, and, under certain circumstances, other acids. He has described a particular formed vessel to be used as a retort, but has not exhibited any figure, as the vessel may be variously constructed without deviating from the general principle. Steam, under great pressure, is proposed and most approved as the heating material; but fire may be applied directly to the under part of the vessel, and effect the same object.

Thus a variety of changes may be made in the modes of conducting the operation, all of which come within the contemplation of the patentee, and are claimed by him under the present patent.

Ceruse is the only white used in oil paintings. Commonly, it is adulterated with a mixture of chalk in the shops. It may be dissolved without difficulty in the acetic acid, and affords a crystallizable salt, called *sugar of lead*, from its sweet taste. This, like all the preparations of lead, is a deadly poison. The common sugar of lead is an acetate; and *Goulard's extract*, made by boiling litharge in vinegar, a *subacetate*. The power of this salt, as a coagulator of mucus, is superior to that of the other. If a plate of zinc be suspended, by a thread, in a solution of acetate of lead, the lead will be revived, and form an *arbor Saturni*. The acetate, or sugar of lead, is usually crystallized in needles, which have a silky appearance. They are flat four-sided prisms, with pointed summits; specific gravity, 2.345. It is soluble in three times and

a half its weight of cold water, and in somewhat less of boiling water.

Acetate and subacetate of lead in solutions have been used as external applications to inflamed surfaces, scrofulous sores, and as eye-washes. In some extreme cases of hemorrhage from the lungs and bowels, the former salt has been prescribed, but rarely, and in minute doses, as a corrugant or astringent. The colic of the painters shows the very deleterious operation of this metal when introduced into the system in the minutest quantities at a time. A course of sulphuretted hydrogen waters, laxatives (of which sulphur, castor-oil, Epsom-salts, or calomel, should be preferred), a mercurial course, the hot sea-bath, and electricity, are the appropriate remedies. Dealers in wines have occasionally sweetened their acid wines with litharge, or its salts. This nefarious adulteration is at once detected by the use of sulphuretted hydrogen water, which will throw down the lead in the state of a dark brown sulphuret. Burgundy wine, and all such as contain tartar, will not hold lead in solution, in consequence of the insolubility of the tartrate. The proper counter-poison for a dangerous dose of sugar of lead is solution of Epsom or Glauber salt, liberally swallowed; either of which medicines instantly converts the poisonous acetate of lead into the inert sulphate. Sugar has been found to neutralize the poisonous action of acetate of lead, and therefore may be regarded as an excellent antidote to it.

League; a measure of length, containing more or fewer geometrical paces, according to the different usages and customs of countries. A sea league contains 3000 geometrical paces, or three English miles. The French league sometimes contains the same measure, and, in some parts of France, it consists of 3500 paces. The mean or common league consists of 2400 paces, and the little league of 2000. Twenty common Spanish leagues make a degree, or 69½ English statute miles. The German league (*meile*) contains four English geographical miles. The Persian league is also equal to four such miles, being very near to what Herodotus calls the length of the Persian *parasang*, which contains 30 *stadia*, eight of which make a mile. See Mile.

Leech; a genus of molluscous animals, which have an oblong body, a mouth surrounded by a lip, and a disc at the posterior extremity, by both of which they can affix themselves to bodies. In the mouth are three small jaws, tongues, or plaits of skin, by which they are enabled to extract the blood of other animals, that forming their principal nourishment. Leeches are hermaphrodites, and some species are viviparous. They occur in ponds and streams, in almost all countries. They derive their principal interest from the use made of them as a remedial agent. There are several of the species which are capable of being thus used, though it is commonly supposed that only two sorts are proper. The employment of leeches in France may be judged of from the circumstance that the hospitals of Paris require an annual supply of several hundred thousands. In Philadelphia, in America, the supply required is from 150,000 to 200,000. The leech, when forcibly pulled away whilst sucking, is very apt to leave the teeth, or plaits of skin, spoken of above, in the wound, occasioning pain and inflammation of the part; the leech is also rendered incapable of again biting. The most certain method of inducing these animals to bite is to cleanse the skin thoroughly: the leeches should be exposed to the air for a short time previous to their application, as by this means they will bite more freely. If they are voracious, they may be applied to the part by being held lightly in the fingers, or they may be placed in a cup which is to be inverted over the part from which the blood is to be drawn. They should not be disturbed whilst sucking, nor the patient be exposed to too great warmth, or they will fall off; this they should always be permitted to do of their own accord. They are made to disgorge, by putting them in a weak solution of common salt; and, if they have not been injured, they may be used five or six times. They are taken either by hand or by means of a gauze net. In keeping them, great care should be taken to renew the water frequently, and not to place too many in the same reservoir, but to remove speedily all that may die. Notwithstanding every precaution that can be taken, they will sometimes perish in great numbers, apparently from an epidemic disease. It appears that, in such cases, the use of charcoal is the best preventive: for this purpose, the bottom of the reservoir is to be strewed with small pieces of this substance, kept down by moss. In 1821, France is said to have exported 1,500,000, and, in 1829, 33,650,000 leeches. The greater part of the leeches employed in this country are brought from Holland.

Leeward, to, denotes towards that part of the horizon which lies under the lee, or whither the wind blows.

Legato; a word used in opposition to *staccato*, and implying that the notes of the movement or passage to which it is affixed are to be performed in a close, smooth, and gliding manner, holding each note till the next is struck.

Leghorn Plat. This name is given to a peculiar species of manufactured straw of great durability and beauty.

During the last war the importation of hats, and similar articles, manufactured of the fine straw grown for that purpose, and known by the name of Leghorn plat, was almost entirely put an end to. The natural consequence was an extraordinary degree of encouragement of our home manufactures of platted straw, by the wives and children of the agricultural labourers of Bedfordshire, Hertfordshire, and Buckinghamshire. At the conclusion of the war this branch of trade fell into the usual channels, and bonnets and hats of genuine Leghorn plat soon found their way again into our market.

The Leghorn straw, being much more slender than the English, may be used whole for the finest articles, by which means the plat is rendered more even, pliable, and durable, than that of equal fineness made from split straw. It is also much superior in colour. To which we may add that the Leghorn plat admits of being joined by knitting the adjacent edges together, instead of overlapping and sewing them, as is the case with English plat.

The process of platting straw in the Italian manner may easily be explained. The ears are cut off the straw, and the straws sized as to length and thickness, and also colour. Thirteen straws are then taken and tied together at one end; they are then divided into a right angle, placing six straws on the left side, and seven on the right. The seventh or outermost on the right is to be turned down by the finger and thumb of the right hand, and brought up under two straws, over two, and under two, and thus

seven straws will be placed again on the right side of the angle; and so on alternately, doubling and platting the outermost seventh straw from side to side, until it becomes too short to cross over so as to double on the other side of the angle; then another straw is to be taken, and put under the short end, at the point of the angle in the middle of the plat; and, by another straw coming under and over the joined one from both sides of the angle, in the operation of platting, it will become fastened, the short end being then left out underneath the plat, and the newly fastened straw taking its place on that side of the angle to which the short straw was directed; and thus the platting is continued, until a piece of about twenty yards long is completed. The short ends which are left out are then cut off with scissars.

Legion; a division of the Roman army. Under Romulus it was composed of 1000 foot and 100 horse, selected from each of the three tribes. The body thus selected (hence the name *legio*) amounted, therefore, to 3300 men. In the time of Polybius, a legion consisted of 4200 men, and it was finally increased to 6200 foot. All the soldiers of a legion were Roman citizens: no slaves were admitted, except in cases of the most pressing necessity; nor any citizen under seventeen years old, except in peculiar circumstances of danger. There was commonly an equal number of auxiliaries attached to each legion, so that, in the later periods of Roman history, we must understand by a legion a corps of 9000 or 10,000 men. The foot of each legion, when it consisted of 3000 men, were divided into ten cohorts, and each cohort into three companies (*manipuli*) of 100 each, hence called *centuriæ*. When the legion was enlarged, the same division was still retained, with the difference that each *manipulus* was now divided into two *centuriæ*, and each *centuria* into ten *decuriæ*.

The commander of a legion was styled the *legatus*. Sometimes, instead of a legate, six military tribunes were appointed from each, who commanded in succession, each for the space of a month, under the direction of the consul. The principal standard of a legion was a silver eagle: and the legions were named from their commander (as the *Claudian legion*), or from the place where they were stationed, or from some deity, or from birds, or from some remarkable event. In the time of Augustus the army consisted of twenty-five legions. *Legion* is also used, proverbially, to signify a large and indefinite number of persons or things. This term was revived in the time of Napoleon, and has since been commonly applied to a body of troops of an indefinite number, and usually of different kinds. Such legions are mostly formed at the beginning of a war, and dissolved at the close. Of this sort were the English-German legion, and the Russian-German legion, in the last war for the independence of Europe. The French national guards were divided into legions and cohorts. After the dissolution of the army raised by Napoleon in 1815, the remains of which had retired beyond the Loire, the new French army was divided into legions, which were named from the departments. This arrangement, however, was abolished towards the close of the year 1820.

Legion of Honour; an order instituted by Napoleon, while consul, May 19, 1802, for military and civil merit. The proposition produced much debate in the legislative body, and passed after a strong opposition. It was the object of Napoleon to kindle a spirit of ambition, the most necessary national element for the support of wars, of which he foresaw that it would be necessary for him to wage many; and for this purpose the institution was admirably calculated. At the same time it cannot be denied that, abstractly considered, it is to be regretted that a nation which had just declared itself so loudly for liberty should appear so eager for ribands—an invention of those very times against which the revolution was directed. Moreau, who was altogether opposed to Napoleon, ridiculed the institution. The cross of the legion of honour was given to all who had previously received a military weapon as a mark of honour, and to a great number of new members. Its effect upon the soldiers was very great. After Napoleon's assumption of the imperial dignity, the statutes received some modifications. The oath was originally as follows: "I swear, on my honour, to devote myself to the service of the republic, to the preservation of the integrity of its territory, to the defence of its government, its laws, and the property by them consecrated; to oppose, by every means which justice, reason, and the laws authorise, all acts tending to re-establish the feudal system, or to revive the titles and distinctions belonging to it; finally, to contribute to the utmost of my power to the maintenance of liberty and equality."

After Napoleon became emperor, the form of the oath was somewhat changed. The members swore to devote themselves to the service of the empire, to the preservation of the integrity of the French territory, to the defence of the emperor, to the support of the laws, and of the property which they had made sacred; to combat, by all the means which justice, reason, and the laws authorised, every attempt to re-establish the feudal *régime*, and to concur, with all their might, in maintaining liberty and equality.

The decoration consisted of a star containing the portrait of Napoleon, surrounded by a wreath of oak and laurel, with the legend *Napoléon, empereur et roi;* on the reverse was the French eagle with a thunderbolt in his talons, and the legend *Honneur et patrie.* The star of the *légionnaires* was of silver, that of the officers of gold, and was suspended from a red riband with a white margin. The order consisted of grand-crosses (*grand aigle*), who wore the cross on a broad riband hanging over the left shoulder, and a star on the left side of the breast; of grand-officers, who wore the cross in the button-hole, and a star, somewhat smaller, on the left side; of commanders, who wore the cross round the neck; of officers, who wore the gold cross with a bow in the button-hole; and of legionaries, who wore the silver cross with a simple riband in the button-hole. The legion was composed of sixteen cohorts, each of which had its seat in a different city, and contained 407 members; the whole number was, therefore, at first, 6512. Each cohort had a chancellor, treasurer, and chief; the whole order a grand-chancellor and grand-treasurer. The pension of a grand-officer was 5000 francs annually; of a commander, 2000; of an officer, 1000; of a legionary, 250 francs. There was also an institution for the education of the daughters of members of the legion of honour at Ecouen, under the care of Madame Campan.

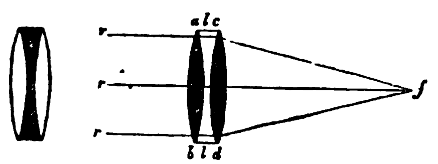
After the restoration of the Bourbons, the order underwent essential changes. The head of Henry IV. was substituted for that of Napoleon, with the

legend *Roi de France et de Navarre*; and, on the reverse, the *fleur-de-lis* took the place of the eagle. The grand-crosses were limited to 80, the grand-officers to 160, the commanders to 400, the officers to 2000: the number of the legionaries was left unlimited. New members received no pensions, whilst those of the old members exceeded the prescribed sum; but, on the death of the old members, the new ones were to receive their pensions. Foreign members received no pensions. It was evident that the legion of honour was coldly treated by the Bourbons, who restored the old orders. The members created during the hundred days were, of course, not acknowledged by the Bourbons; but, in 1831, Gen. Lamarque obtained their acknowledgment, by a spirited speech in the chamber of deputies, for which they sent him a sword with an inscription. Military honours are paid to the members of the legion, as they are also to the bearers of the *croix de Juillet*, which has been granted to 1528 persons who distinguished themselves during the struggle of July, 1830. This cross takes precedence of that of the legion of honour.

Lemma, in *mathematics*, denotes a preliminary proposition, laid down in order to clear the way for some following demonstration, and prefixed either to theorems, in order to render their demonstration less perplexed and intricate, or to problems, to make their solution more easy and short.

Lemonade; a drink made of water, sugar, and the juice of lemons. Prepared in this simple way, it is a very grateful beverage in warm weather, or to feverish patients. The taste is more agreeable, if the sugar is rubbed with the peel of the lemon, so as to imbibe the oil contained therein; but the lemonade is thus rendered stimulant rather than cooling, and many persons suffer from headach in consequence. Cream of tartar is frequently used instead of lemon-juice.

Lens, in *dioptrics*, properly signifies a small ground glass, which either collects the rays of light into a point, in their passage through it, or makes them diverge, according to the laws of refraction. Lenses have various figures, that is, are terminated by various surfaces, from which they acquire various names. Some are plane on one side, and convex on the other; others convex on both sides: both of which are ordinarily called *convex lenses*, though, when we speak accurately, the former is called *plano-convex*. Again, some are plane on one side, and concave on the other; and others are concave on both sides; which are both usually ranked among the concave lenses, though, when properly distinguished, the former is called a *plano-concave*. Others, again, are concave on one side, and convex on the other, which have the name *meniscus*. In every lens, terminated in any of the forementioned manners, a right line, perpendicular to the two surfaces, is called the *axis of the lens*, which axis, when both surfaces are spherical, passes through both their centres; but, if one of them be plane, it falls perpendicularly upon that, and goes through the centre of the other.



The effect of a convex lens is to converge the rays of light which pass through it, of which an example is given in the preceding engraving.

In the old optical arrangement for refracting light it was common to employ a lens of considerable thickness. When the focus was short, a plano-convex "lump" was usually resorted to, and this rude apparatus is still used in the magic lantern. In the foregoing wood-cut two double convex lenses, *a b*, *c d*, supply the place of the *lump*, and a slight intervening space, *l l*, is left between them. The horizontal rays *r*, *r*, *r*, impinging on the convex surfaces, are thus refracted, and form a focal point at *f*.

In the same diagram we give the combination of lenses which are termed *achromatic*, from their power of transmitting the light in a purely colourless state. The common lens partly decomposes the rays which pass through it, owing to their possessing different degrees of refrangibility; but by judiciously combining three lenses in the same frame, each of which possesses a different degree of density, the light is transmitted without colour. See Optics.

Leprosy; a name given to several different diseases. The elephantiasis is sometimes called *leprosy of the Arabs*. The *leprosy of the Jews* is distinguished by white, cutaneous spots, composed of smaller spots, which appear sometimes in one place and sometimes in another, and are covered with a rough scaly matter. It appears to have been the *leuce* of the Greek writers. The *Greek leprosy* is characterized by hard, insensible tubercles, which appear upon the skin, and are accompanied by a progressive insensibility and the loss of the voice. It is endemic in Egypt, Java, and some parts of Norway and Sweden. The use of unhealthy articles of food seems to be one of its causes. It is hereditary and contagious. It was introduced into western Europe in the time of the crusades, but has gradually disappeared. The tubercles which characterize leprosy appear in different parts of the skin: they are hard, rough, and numerous, and cause the loss of the hair at the places where they appear. They finally terminate in ulcers, which penetrate even to the bone, producing a caries. They also cause the separation of parts of the body, the toes and fingers, for example, dropping off. These symptoms are accompanied with a languor in the motions, a dulness of the senses, a change of the voice, offensive breath, and lethargy.

There are three sorts of leprosy—the squamous, or scaly; the crustaceous, in which the skin is covered with crusts; and the tuberculous. The remedy recommended for this disgusting disease is light food, such as vegetables, soups, milk: sulphur baths, sudorific drinks, and mercury, are sometimes prescribed. But all remedies are too frequently unavailing. In the middle ages, leprosy, under all the forms of disease to which this term has been applied, seems to have been very common and general. It should, however, be observed that almost all cutaneous disorders were considered as of a leprous nature, and treated as such. From the sixth to the fifteenth century, these loathsome disorders attracted the attention of lawgivers and of the benevolent, and we find numerous ordinances relating to lepers, affecting their civil rights, and great numbers of lazar-houses in all the countries of Europe. In the historians of those times, therefore, we are to consider the word *leprosy* as used indiscriminately for all cutaneous diseases; and we may well be astonished and shocked to find that all such patients were treated somewhat

after the manner prescribed in Leviticus for the Jewish leprosy. They were, in fact, treated as civilly dead: their funeral obsequies were performed, and masses said for the benefit of their souls. Their marriage ties were dissolved; but a leper might enter into a new connexion with a person who was also afflicted with the disease. They were allowed to enter the cities at certain seasons, but were required to give notice of their approach by sounding a rattle. The consequences of such a treatment may be easily imagined. The improved condition of the lower classes, in food, clothing, and manner of living in general, and the advancement of medical science, have contributed to eradicate this loathsome and disgusting malady.

Levee; an embankment on the margin of a river, to confine it within its natural channel. The lower part of Louisiana, which has been formed by encroachments upon the sea, is subject to be inundated by the Mississippi and its various branches, for a distance of more than 300 miles. In order to protect the rich lands on these rivers, mounds are thrown up, of clay, cypress logs, and green turf, sometimes to the height of fifteen feet, with a breadth of thirty feet at the base. These, in the language of that part of the country, are called *levées*. They extend for hundreds of miles; and, when the rivers are full, cultivated fields, covered with rich crops and studded with villages, are seen lying far below the river courses. The giving way of these *levées*, sometimes occasioned by a sudden and violent pressure of the water and sometimes by accidental perforations, is called a *crevasse*, or disruption.

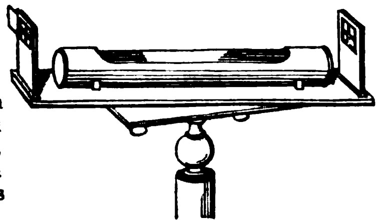
Levee-en-masse (universal rising); a military expression for the rising of a whole people, including all capable of bearing arms who are not otherwise engaged in the regular service. When animated by patriotic feelings, it is the most formidable obstacle which an enemy can encounter; and it is unconquerable, if favoured by the nature of the ground, because almost every advantage is on the side of the people. They fight on their own soil; they know the ground; they find support and assistance in every house, from every woman and child; they fight for their own hearths; they enclose the enemy on all sides, and can destroy whatever may be useful to him, cut off his communications, pursue, annoy, disturb, assail, harass him incessantly, so that he can effect nothing except getting possession of the strong places. It is called *Landsturm* (landstorm), in German, in distinction from the *Landwehr* (militia). This distinction was first made in 1796, when the peasants of Bavaria and Franconia fell upon the rear of the flying French, under Jourdan, with much success. The *Landsturm* was yet more effective in 1799, and, in 1813, the governments of Northern Germany called it forth in every part of the country. It consisted of every male person, capable of bearing arms of any sort, whom age or other reasons exempted from the militia service. Orders were issued to turn every thing into weapons, to defend the country by every means, and to injure the enemy in all possible ways, by destroying provisions and wells, attacking stragglers, intercepting couriers, and escorting prisoners. The *Landsturm* was useful at the siege of several fortresses. Its organization was founded on municipal divisions.

Napoleon ordered the *levée-en-masse* when the allies entered France, and it threatened to become dangerous to them; but the capture of Paris put an end to the war. We all know how effectual the *levée-en-masse* was in Spain, where even women took part in it, and in the Tyrol, under Hofer. The French national guard, with its different classes, might be considered a *levée-en-masse*, organized on a gigantic plan. The chief difference between a *levée-en-masse* and militia is, that, in the former, all persons are comprised not included in the latter; that they do not march far from home; and that their service is more irregular, and even owes its strength, in some measure, to this irregularity.

Level; a mathematical instrument, used for drawing a line parallel to the horizon, and continuing it at pleasure, and, by this means, for finding the true level, or the difference of ascent or descent between several places, for conveying water, draining fens, placing the surfaces of floors, &c., level, and for various other purposes in architecture, agriculture, hydraulics, surveying, &c. There is a great variety of instruments for this purpose, differently constructed, constituted of different metals, according to the particular purposes to which they are applied; as the carpenter's level, mason's level, balance level, mercurial levels, surveying and spiral levels; but, however their construction may vary, they may all be referred to the following three classes: 1. those in which the vertical line is determined by a suspended plumb-line or a balance-weight, and the horizontal position is shown by a line perpendicular to it; 2. those which determine a level line by the surface of a fluid; 3. spirit levels, which point out the horizontal direction by a bubble of air floating in a fluid contained in a glass tube.

1. Those of the first kind, depending upon the plumb-line, are very common, but not very accurate. The simplest form is that of two rulers united in the form of the letter L; they must be exactly perpendicular to each other; then, if a plumb-line be suspended from the top of the vertical ruler, and the edge thereof be made to coincide with the plumb-line, the other ruler must be horizontal. This, when applied to the top of a wall, a beam, or a floor, will show whether it is horizontal. Sometimes the instrument is formed like the letter A, the plumb-line being suspended from the vertex, and the two legs set on the surface to be levelled. The line hangs opposite to a mark made on the middle of the cross ruler when the feet are on the same level. At other times the horizontal piece crosses the perpendicular at its foot, and the plumb, suspended from the top of the perpendicular, is received in an opening at their junction. 2. The *water level* shows the horizontal line by means of a surface of water or other fluid, founded on the principle that water always places itself horizontally. The most simple kind, made of a long wooden trough, which is filled with water, shows on its surface the line of level. This is the ancient *chorobates*. The water level is also made with two cups fitted to the two ends of a straight pipe, an inch in diameter, and four feet long. The water communicates from one cup to the other; and, this pipe being movable on its stand by a ball and socket, when the two cups are seen to be equally full of water, their two surfaces mark the line of level. This instrument, instead of cups, may also be made with two short cylinders of glass, three or four inches long, fastened to each extremity of the pipe with wax or mastich. The pipe, filled with coloured water, shows

itself through the cylinders, by means of which the line of level is determined, the height of the water, with respect to the centre of the earth, being always the same in both cylinders. This level, though very simple, is yet very commodious for levelling small distances. 3. The *spirit* or *air level* shows the exact level, by means of a bubble of air, enclosed, with some fluid, in a glass tube of an indeterminate length and thickness, and having its two ends hermetically sealed. When the bubble fixes itself at a mark in the middle of the tube, the case in which it is fixed is then level. When it is not level, the bubble will rise to one end. This glass tube may be set in another of brass, having an aperture in the middle, where the bubble may be observed. The liquor with which the tube is filled is oil of tartar, which is not liable to freeze, as common water, nor to rarefaction and condensation, as spirit of wine is. A level which owes its operation to the tendency which all fluids have to a state of equilibrium is shown beneath. To make this level applicable to surveying, it is provided with apertures and cross wires, along which the sight is directed.



Lever, in *mechanics*; an inflexible right line, rod, or beam, supported, at a single point, on a fulcrum or prop, and used for the raising of weights, being either void of weight itself, or at least having such a weight as may be commodiously counterbalanced. The lever is the first of those called *mechanical powers*, or *simple machines*, as being, of all others, the most simple; and is chiefly applied for raising weights to small heights. (See Mechanics.)

Ley, or Lees; a term usually applied to any alkaline solution made by levigating ashes that contain an alkali. Soap-lees is an alkali used by soap-boilers, or potash or soda in solution, and made caustic by lime. Lees of wines are the refuse, or sediment, deposited from wine standing quiet.

Leyden Phial, in *electricity*, is a glass phial or jar, coated both within and without with tin-foil, or some other conducting substance, which may be charged, and employed in a variety of useful and entertaining experiments. Glass of any other shape, so coated and used, has also received the same denomination. A vacuum produced in such a jar, &c., has been named the *Leyden vacuum*. (See Electricity.)

Li (called also *caxa*); the common copper coin in China, with a square hole in the middle, and an inscription on one side. The copper is alloyed with lead, and the coin, which is cast, is very brittle. Ten lis make one candareen, 100 a mas, 1000 a liang, or tale.

Libra; the Roman pound unit for weighing. The ancient Romans reckoned money also by pounds, and a libra of silver was worth about three pounds sterling. This word passed over to the various nations of Latin descent or mixture.

Libration of the Earth is sometimes used to denote the parallelism of the earth's axis in every part of its revolution round the sun.

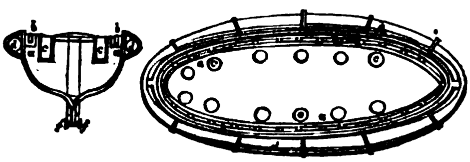
Libration of the Moon. Very nearly the same face of the moon is always turned towards the earth, it being subject to only a small change within certain limits, those spots which lie near the edge appearing and disappearing by turns; this is called its *libration*. The moon turns about its axis in the same direction in which it revolves in its orbit. Now the angular velocity about its axis is uniform, and it turns about its axis in the same time in which it makes a complete revolution in its orbit; if, therefore, the angular motion about the earth were also uniform, the same face of the moon would always be turned towards the earth; for, if the moon had no rotation on her axis, when she is on opposite sides of the earth she would show different faces; but if, after she has made half a revolution in her orbit, she has also turned half round her axis, then the face which would otherwise have been shown will be turned behind, and the same face will appear. Thus, if the moon's angular velocity about her axis were always equal to her angular velocity in her orbit about the earth, the same side of the moon would be always towards the earth; but, as the moon's angular velocity about her axis is uniform, and her angular velocity in her orbit is not uniform, these angular velocities cannot continue always equal, and therefore the moon will sometimes show a little more of her eastern parts, and sometimes a little more of her western parts. This is called a *libration in longitude*. Also the moon's axis is not perpendicular to the plane of her orbit, and therefore, at opposite points of her orbit, her opposite poles are turned towards the earth; thus her poles appear and disappear by turns. This is called a *libration in latitude*. Hence nearly one-half of the moon is never visible at the earth, and therefore nearly one-half of its inhabitants, if it has any, never see the earth, and nearly the other half never lose sight of it. Also, the time of its rotation about its axis being a month, the length of the lunar days and nights will be about a fortnight each. It is a very extraordinary circumstance that the time of the moon's revolution about her axis should be equal to that in her orbit.

Lieutenant. This word, like *captain* and many others, has received gradually a much narrower meaning than it had originally. Its true meaning is a *deputy*, a *substitute*, from the French *lieu* (place, post) and *tenant* (holder). A *lieutenant général du royaume* is a person invested with almost all the powers of the sovereign. Such was the Count d'Artois (afterwards Charles X.) before Louis XVIII. entered France, in 1814. The Duke of Orleans, before he accepted the crown as Louis-Philip, was appointed to the same office by the chamber of deputies. *Lieutenant-general* was formerly the title of a commanding general, but at present it signifies the degree above major-general. *Lieutenant-colonel* is the officer between the colonel and major. *Lieutenant*, in military language, signifies the officer next below a captain. There are first lieutenants, and second or *sous-lieutenants*, with different pay. A lieutenant in the navy is the second officer next in command to the captain of a ship. According to the new organization of the French navy, of 1831, there are *lieutenants de vaisseau* and *lieutenants de frégate*, formerly called *enseignes de vaisseau*. The latter can command only in the absence of the former. In this country, the *lord-lieutenant* of a county has the authority to call out the militia in case of invasion or rebellion. The governor of Ireland is also called *lord-lieutenant of Ireland*. In some English colonies,

jointly under a *governor-general*, the chief magistrate of each separate colony is called *lieutenant-governor*.

Life-boat, a buoyant vessel, employed when the weather is tempestuous to save the crews of shipwrecked vessels. The latest improvements in the construction of life-boats have become the subject of a patent granted to Lieut. Cook, R. N. The improvements described under this patent consist, first, in covering the deck of the boat with a water-tight canvass envelope, secured by water-tight joints all round its edges, and having bags formed in it, which descend below the deck, to contain the legs of the persons sitting in the boat.

Secondly, in the application of buoyant fenders placed all round the outside of the gunwale of the boat, which protect the boat when going alongside of a wreck, and also serve to keep the boat buoyant, in case she should have her bottom stove in. Thirdly, in improvements in the ballasting of a boat, with long bars of metal placed on each side of the keel, resting upon pins or bolts, and suspended by chains; these bars of ballast can be let go to relieve the boat of the weight in case she should fill with water. Fourthly, in the construction of the hooks or holdfasts of the ropes, by which the sails are made fast, or other ropes used in the boat, and are so contrived that they can be let go at a moment's notice, in case of a sudden squall coming on.



The accompanying wood-cut is a plan of a boat, showing some of the patentee's improvements. Beside it is a transverse section; *a a* is a shelf, placed all round the inside of the boat, or it may form part of the deck. The water-proof covering extends over the inside of the boat like a deck, and is jointed to the shelf water-tight at *b b*, by forming a channel in a groove all round in the shelf; the edges of the water-proof covering are introduced into the groove, and firmly secured by rods of wood or metal fastening into the groove by screw bolts or otherwise; *c, c*, are bags formed in the covering to contain the legs of the persons sitting in the boat.

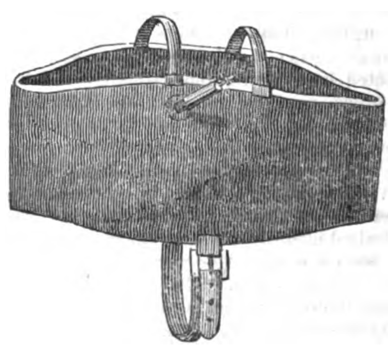
In order to let out any water which may remain on the deck or covering, holes are made in the sides of the boat through the gunwale, usually stopped tight by screw plugs, but which can be removed and replaced as required; *d, d*, are the buoyant fenders, which are formed of strong water-proof canvass, and filled with cork cuttings, shavings, or any other light material, extending round all the sides of the boat, and are firmly secured to it by lashings. Bars of metal, forming additional ballast to the boat, are shown at *f, f;* these bars rest upon bolts, projecting on both sides of the keel of the boat, and are kept in that situation by collars formed upon the bolts. In case of the boat becoming swamped, these bars can be removed by chains attached to their ends, and let fall away, thereby relieving the boat of their weight.

Life-Preservers. A variety of contrivances under this title have been brought before the public, two or three of which may advantageously have a place in this article. We may commence with Mr. Murray's apparatus, which he calls an "Invention of an effective and unfailing method for forming an instantaneous communication with the shore in shipwreck, and illuminating the scene in a dark and tempestuous night." The apparatus which Mr. Murray suggests is, "an arrow of peculiar construction, about eighteen inches long, weighing about six ounces and a half, and having a cord attached to it, which is shot from a common blunderbuss, or a three-pounder swivel, from the shore to the vessel." This arrow is barbed with iron, so as to fix itself in what it strikes. The cord thus conveyed on board is strong enough to bear the weight of a rope, which can thus be drawn to the vessel, and the necessary communication will be effected. There is a further contrivance, of a combustible substance, which, when necessary, can be attached to the arrow, and which, catching fire by the action of the air, during the arrow's flight, to use the author's phrase, "illuminates the scene." It is evident that this may be used in many situations where Captain Manby's apparatus is impracticable, and is besides not subject to the mischance that frequently defeats the success of his apparatus, the snapping of the rope.

The efficacy of this invention has been established by a variety of experiments, in the course of which it was found practicable to throw a line 170 yards against a strong gale of wind—and, with a steady aim, whatever was the direction of the wind.

The immense practical utility of such an invention is shown from several considerations. The loss of life by shipwreck, on the British coast, is more considerable than is generally supposed. It has been computed that in twenty years prior to 1812 more than 800 persons perished on the coast of Norfolk alone, exclusive of the crews of vessels known to have been totally lost. By far the greater number of shipwrecks take place at distances from the shore of from 50 to 100 yards, and therefore within the reach of the arrow.

Life-Preserver for Water. The most simple apparatus for the above purpose is that invented by Mr. Daniel and represented beneath:



The body of the machine, which is double throughout, is made of pliable water-proof leather, large enough to admit of its encircling the body of the wearer, whose head is to pass betwixt the two fixed straps, which rest upon the shoulders; the arms of the wearer pass through the spaces on the outside of the strap, one on each side, admitting the machine under them to encircle the body like a large hollow belt. The strap on the lower part of the machine is attached to the back of it, and by passing betwixt

the thighs of the wearer, holds the machine sufficiently firm to the body, without too much pressure under the arms. The machine, being thus fixed, is inflated by the wearer blowing in from his lungs, through a small stop-cock, a sufficient quantity of air to fill it, which air is retained by afterwards closing the aperture. When filled with air, it will displace a sufficient quantity of water to prevent four persons from sinking beneath the surface.

The inventor recommends this life-preserver to be prepared as follows: viz. to select sound German horse-hides, and to cut a piece six feet long and two feet six inches wide, which is first to be curried, and then rendered water-proof by any good varnish.

The leather is to be nailed on a board, and the varnish applied upon it; it is then to be placed in an oven several times, the varnish being each time repeated, till the leather is completely covered; it is then cut in the form of a jacket, as above described, and neatly and firmly stitched; the seams and stitches are afterwards to be perfectly secured by the following black elastic varnish:

Gum-asphaltum, two pounds; amber, half a pound; gum-benzoin, six ounces; linseed-oil, two pounds; spirits of turpentine, eight pounds; and lamp-black, half a pound; united together in an earthen vessel with a gentle heat.

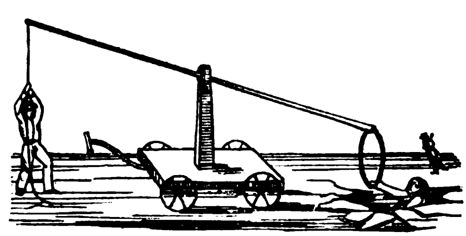
The machine, when properly made, resembles a broad belt, or circular girdle, composed of two folds of pliable leather attached together, and perfectly impervious to water. When used, the wearer introduces his head and arms within the circle, the stop-cock in front; the two fixed straps rest one upon each shoulder, to prevent the belt from sinking down; the lower strap is then brought between the thighs, and buckled in front, which prevents the machine from being forced back. The machine is then inflated by application of the mouth to the stop-cock in front, and, when properly filled, the turning of the cock retains the air in the machine, and expands it so much as to displace a quantity of water amply sufficient, not only to sustain the wearer, but a further weight, if necessary, buoyant in the water.

A great number of cases have occurred by which the efficacy of this life-preserver has been fully manifested. Among others the following may be adverted to:—The Alert privateer struck on a rock near the Western Isles, and went to pieces in five minutes. Thirteen of the crew saved themselves by clinging to pieces of the wreck; but the rest, consisting of sixty-four foremast men, and all the officers except the surgeon, perished. The surgeon, though unable to swim, supported himself amidst waves running mountains high by one of these life-preservers, with which he happened to have provided himself, until the arrival of a Portuguese boat, which put off to his assistance, and took him up about a mile from the shore.

Another instance of the utility of this life-preserver may be adduced. Two gentlemen and two ladies, in a pleasure-boat, set sail from Yarmouth about four o'clock in the afternoon, with a view to reach the city of Norwich, a distance of thirty miles, that evening: the wind blew hard at south-west. One of the life-preservers was taken on board, though without the smallest fear that any occasion for its use would occur; and it was with a view to amusement rather than otherwise jocosely filled as they went along, by one of the gentlemen. The precaution proved most fortunate; for, on tacking to enter Norwich river, at a part of the water called Braydon, two miles over, a sudden gust overset the boat, and plunged the whole company into the water, which was extremely rough. The gentleman with the machine having reached the other, who, inexpert at swimming, could scarcely support himself, directed him to lay hold of the collar of his coat, over which the machine was fixed. This being done, he proceeded to the ladies, whose clothes kept them buoyant, though in a state of fainting when he reached them; and, taking one of them under each arm, the violence of the wind drifted all four upon Burgh Marshes, where the boat had already been thrown. Here, after procuring such refreshment and assistance as they required, they again set sail in their own boat, and arrived at Norwich by eleven o'clock the same night.

It would be useless to multiply testimonies of this nature, as those adduced very clearly show the services which this very simple machine is capable of rendering, in cases of the greatest peril from shipwreck. At seaports, and wherever accidents on water are likely to occur, nothing has yet been devised better calculated for general utility; and it is highly desirable that the plan should be adopted of keeping one or more of these life-preservers in known and convenient situations. Sadler, the celebrated aëronaut, was provided with one of them, which he considered a necessary part of his apparatus in his aërial voyages, and which enabled him to contemplate, without being appalled, the circumstance of being compelled to descend even upon the sea, a disaster which actually occurred near the mouth of the river Mersey, Liverpool, while accomplishing the adventurous excursion in his balloon from Ireland to England.

Life-Preserver for Ice. The number of fatal accidents which have occurred from the fracture of this brittle material, even when help was within a few yards of the sufferers, renders it necessary that some simple plan should be adopted for opening a communication without endangering the life of the assistant. A cheap machine for this purpose is shown beneath:



It consists of a lever, supported by a movable frame, which may readily be transported to any required point. At one extremity of the lever is attached a large hoop, which may be raised by a slight force at the opposite end. The great advantage of this plan is, that the person who renders assistance does so without endangering himself; and the hoop, being drawn nearly in a perpendicular direction, prevents the person who is immersed from being wounded by the edge of the ice.

Ligament, in *anatomy;* a strong, compact substance, serving to join two bones together. A ligament is more flexible than a cartilage, not easily ruptured or torn, and does not yield, or at least yields very little, when pulled.

Ligature, in *surgery,* is a cord, band, or string; or the binding any part of the body with a cord, band, fillet, &c., whether of leather, linen, or any other matter. Ligatures are used to extend or replace bones that are broken or dislocated; to tie the patients down in lithotomy and amputations; to tie upon the veins in phlebotomy, on the arteries in amputations or in large wounds; to secure the splints that are applied to fractures; to tie up the processes of the *peritoneum,* with the spermatic vessels, in castration; and, lastly, in taking off warts or other excrescences by ligature. The term *ligature* is also used to signify a kind of bandage or fillet, tied round the neck, arm, leg, or other part of the bodies of men or beasts, to divert or drive off some disease.

Ligatures, among printers, are types consisting of two letters or characters joined together; as *ff, fi, fl.* The old editions of Greek authors are extremely full of ligatures; the ligatures of Stephens are by much the most beautiful.

Light is that imponderable body which renders objects perceptible to our sense of seeing. It is one of the most interesting subjects that fall under the contemplation of the philosopher: at the same time it must be acknowledged to be one that is as little understood, and upon which opinions are as much divided, as any of the most abstruse subjects of philosophical enquiry. Some consider light as a fluid *per se;* while others consider it merely as a principle, and attribute it to a sort of pression or vibration propagated from the luminous body through a subtile ethereal medium. The ancients believed it to be propagated from the sun and other luminous bodies instantaneously; but the observations of the moderns have shown that this was an erroneous hypothesis, and that light, like any other projectile, occupies a certain time in passing from one part of space to another, though the velocity of its motion is truly astonishing, as has been manifested in various ways. And, first, from the eclipses of Jupiter's satellites; it was observed by Reaumur that the eclipses of those satellites happen sometimes sooner and sometimes later than the times given by the tables of them, and that the observation was before or after the computed times, according as the earth was nearer to or farther from Jupiter than the mean distance. Hence it was concluded that this circumstance depended on the distance of Jupiter from the earth; and that, to account for it, we must suppose that the light is fourteen minutes in crossing the earth's orbit. The original observations have received some corrections, and it is now found that, when the earth is exactly between Jupiter and the sun, his satellites are seen eclipsed about eight minutes and a quarter sooner than they could be according to the tables; but, when the earth is nearly in the opposite point of its orbit, these eclipses happen about eight minutes and a quarter later than the tables predict them. Hence, then, it is certain that the motion of light is not instantaneous, but that it takes up about 16½ minutes of time to pass over a space equal to the diameter of the earth's orbit, which is nearly 190,000,000 of miles in length, or at the rate of 200,000 miles per second—a conclusion which, it may be added, is placed beyond doubt, by the aberration of the stars discovered by Dr. Bradley.

Upon the subject of the materiality of light, Doctor Franklin observes, in expressing his dissent from the doctrine that light consists of particles of matter continually driven off from the sun's surface, with such enormous swiftness—"Must not the smallest portion conceivable have, with such a motion, a force exceeding that of a twenty-four pounder discharged from a cannon? Must not the sun diminish exceedingly by such a waste of matter, and the planets, instead of drawing nearer to him, as some have feared, recede to greater distances, through the lessened attraction? these particles, with this amazing motion, will not drive before them or remove the least and slightest dust they meet with, and the sun appears to continue of his ancient dimensions, and his attendants move in their ancient orbits." He therefore conjectures that all the phenomena of light may be more properly solved, by supposing all space filled with a subtile elastic fluid, not visible when at rest, but which, by its vibrations, affects that fine sense in the eye, as those of the air affect the grosser organs of the ear; and even that different degrees of vibration of this medium may cause the appearances of different colours. The celebrated Euler has maintained the same hypothesis, urging some further objections to the materiality of light, besides those of Doctor Franklin above alluded to. Newton first discovered that certain bodies exercise on light a peculiar attractive force. When a ray passes obliquely from air into any transparent liquid or solid surface, it undergoes, at its entrance, an angular flexure, which is called *refraction.* The variation of this departure from the rectilineal path for any particular substance depends on the obliquity of the ray to the refracting surface; so that the sine of the angle of refraction is to that of the angle of incidence in a constant ratio. Newton, having found that unctuous or inflammable bodies occasioned a greater deviation in the luminous rays than their attractive mass, or density, gave reason to expect, conjectured that both the diamond and water contained combustible matter—a conjecture which was verified by subsequent discovery.

Doctor Wollaston invented a very ingenious apparatus, in which, by means of a rectangular prism of flint-glass, the index of refraction of each substance is read off at once by a vernier, the three sides of a movable triangle performing the operations of reduction in a very compendious manner. But transparent media occasion not merely a certain flexure of the white sunbeam, called the *mean refraction:* they likewise decompose it into its constituent colours. This effect is called *dispersion.* Now, the mean refractive and dispersive powers of bodies are not proportional to each other. In some refracting media, the mean angle of refraction is smaller, whilst the angle of dispersion is larger. From the refractive power of bodies, we may, in many cases, infer their chemical constitution. For discovering the purity of essential oils, an examination with Doctor Wollaston's instrument is of great utility, on account of the smallness of the quantity requisite for trial. This idea of Doctor Wollaston has been happily prosecuted by M. Biot with regard to gaseous compounds; and we now have accurate tables of the refractive power of all transparent, gaseous, liquid, and solid bodies. Carburet of sulphur exceeds all fluid substances in refractive power, surpassing even flint-glass, topaz,

and tourmalin; and, in dispersive power, it exceeds every fluid substance except oil of cassia. Rays of light, in traversing the greater number of crystallized bodies, are commonly split into two pencils, one of which, called the *ordinary ray*, follows the common laws of refraction, agreeably to the tables alluded to, whilst the other, called the *extraordinary ray*, obeys very different laws. This phenomenon is produced in all transparent crystals whose primitive form is neither a cube nor a regular octahedron. The division of the beam is greater or less according to the nature of the crystal, and the direction in which it is cut; but, of all known substances, that which produces this phenomenon in the most striking manner is the crystallized carbonate of lime, called *Iceland spar*.

If the white sunbeam admitted through a small hole of a window-shutter into a darkened room be made to pass through a triangular prism of glass, it will be divided into a number of splendid colours, which may be thrown upon a sheet of paper. Newton ascertained that if this coloured image, or *spectrum*, as it is called, be divided into 360 parts, the red will occupy forty-five, the orange twenty-seven, the yellow forty-eight, the green sixty, the blue sixty, the indigo forty, and the violet eighty. The red rays, being least bent by the prism from the direction of the white beam, are said to be least refracted, or the least refrangible; while the violet rays, being always at the other extremity of the spectrum, are called the most refrangible. If these differently coloured rays of light be now concentrated on one spot, by a lens, they will reproduce colourless light.

Newton ascribes the different colours of bodies to their power of absorbing all the primitive colours, except the peculiar one which they reflect, and of which colour they therefore appear to our eye. The different coloured rays possess very different powers of illumination. The lightest green, or deepest yellow, which are near the centre, throw more light on a printed page than any of the rays towards either side of the spectrum. The rays of the prismatic spectrum differ from one another also in their heating power, as was first noticed by Herschel. In viewing the sun, by means of large telescopes, through differently coloured darkening glasses, he sometimes experienced a strong heat, attended with very little light, and, at other times, he had a strong light with a little heat. This observation led to his well-known researches upon this subject, from which he concluded that the maximum heat is just without the spectrum, beyond the red ray. Others have found the greatest heat in the red ray itself; but the observations of M. Seebeck have shown that the point of greatest heat was varible, according to the kind of prism which was employed for refracting the rays. When a prism of fine flint-glass is used, the greatest heat is constantly beyond the red; when a prism of crown-glass, the greatest heat is in the red itself.

It has long been known that the solar light is capable of producing powerful chemical changes. One of the most striking instances of it is its power of darkening the white chloride of silver—an effect which takes place slowly in the diffused light of day, but in the course of two or three minutes by exposure to the sunbeam. This effect was formerly attributed to the influence of the luminous rays; but it appears, from the observations of Ritter and Wollaston, that it is owing to the presence of certain rays that excite neither heat nor light, and which, from their peculiar agency, are termed *chemical* rays. It is found that the greatest chemical action is excited just beyond the violet ray of the prismatic spectrum, that the spot next in energy is occupied by the violet ray itself, and that the property gradually diminishes as we advance to the green, beyond which it seems wholly wanting. The sunbeams, in traversing a coloured glass, produce similar effects to those caused by the differently coloured portions of the spectrum. Thus the chloride of silver acquires a black tint behind a blue or violet glass, but does not blacken behind a red or orange glass; on the other hand, it becomes red behind a red glass, and that much more quickly than even in the solar spectrum.

Light produced by coal and oil gases, or by olefiant gas, even when concentrated so as to produce a sensible degree of heat, was found, by Mr. Brande, to occasion no change in the colour of muriate of silver, nor in mixtures of chlorine and hydrogen; while the light emitted by electrized charcoal speedily affected the muriate, and caused these gases to unite, and sometimes with explosion. The concentrated light of the moon, like that of the gases, produced no change. The importance of light to plants is well known: deprived of it, they become white, and contain an excess of saccharine and aqueous particles; and flowers owe the variety and intensity of their hues to the influence of the solar beams. Even animals require the presence of the rays of the sun, and their colours seem materially to depend upon the chemical influence of these rays. A comparison between the polar and tropical animals, and between the parts of their bodies exposed and those not exposed to light, shows the correctness of this opinion. (For an account of the physical affections, and chemical effects of light, see OPTICS.)

LIGHT, in the *fine arts*.—This term is employed by the artist in contradistinction to *shadow;* and the following rules and definitions are given by Mr. Hayter, for the governance of the painter:—

1. Reflecting surfaces tincture the objects reflected on with their colour proportionately with their distance from each other, and the angle under which light operates.

2. The general prevailing colour of light tinctures every object within its influence; for instance, observe the whole hemisphere at the time of a warm setting sun, or the gray effects of a cloudy sky, or a fog.

3. The power of light, particularly sunshine, increases the warmth, and weakens the local colours of all the cold class of colours, which are *blue, green,* and *purple:* for instance, *grass*, which in shade appears a cool refreshing *green*, will appear almost *yellow* in sunshine.

4. The *warmth* of parts or breadths which lie under a partial degree of shade, where the power of lights from surrounding matter prevails, is accounted for by the quantity of such secondary light, and their local colours.

5. When a white surface *reflects* on the *shadowy* part of any colour, it looks paler than the *lighted* parts of such colour; but the power of the shadow holds its influence with regard to light.

6. Glossy surfaces receive the form and colour of all objects locally, according to their purity, and reflect them accordingly, being in such degree mirrors.

7. Every colour that is reflected by its own colour is enriched thereby, according to the strength of light on the reflector.

8. Every colour that is reflected on by its directly opposite colour will be neutralized thereby; such as *green* against *red*, *blue* against *orange*, or *purple* against *yellow*, in an equivalent degree with the power of light.

9. If any two approximate colours reflect the one on the other, the tincture will approach the appearance of that compound which the two colours would make by mixing them.

10. The direct opposite to any of the primitive colours is an equal compound of the other two.

11. The middle colour or medium in a warm effect is *red*.

12. The middle colour or medium between light and darkness, in the gradations of a cold effect, is *green*.

13. Whatever be the colour of a flat surface when viewed directly perpendicular by the visual ray, faintly lighted, must be painted of that colour when unaffected by glittering or reflection, regarding duly the influence of distance and aërial medium.

14. The *certain colours* of all visible matter must give place to their *appearances*, owing to the compounding influence of *light, shade, reflection, various distance, clearness, density*, and prevailing hue or colour of the medium under which *any colour* is seen.

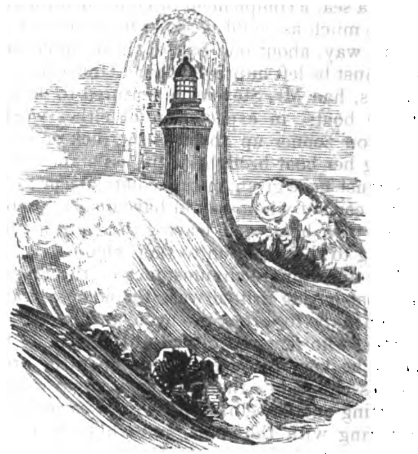
Light, Instantaneous.—There are several species of apparatus for the instantaneous production of light; but our space will permit a description of only one, which is the latest and appears the most meritorious. It forms the subject of a patent granted to Mr. Newton, of the office for patents, Chancery Lane.

The invention consists of two features: a peculiar construction of valve or stopper, which prevents the escape of acid from the bottle, and, though remaining fixed, at all times furnishing a sufficient supply to produce the ignition of the match. This valve or stopper is a leaden plug, screwed into the neck of a glass bottle, about two-thirds filled with sulphuric acid. The plug is cup-shaped on the upper surface, and convex below. One or more exceedingly small perforations are made through this plug for the passage of the acid from within, which is obtained by slightly shaking the bottle, when the drop or globule of the acid which adheres to the under side of the plug, after the bottle has been shaken, finds its way upwards through the small holes by capillary attraction, and which may be aided by the warmth of the hand expanding the air within, thereby assisting the liquid to exude into the cup above; the apertures, however, are too small to allow the damp to enter.

The other feature of novelty is in the matches, which are made of short pieces of wax taper, the size of common dressing pins, on the end of which there is a small globule of mastic, made of an inflammable material, which instantly ignites on being introduced into the cup of the bottle stopper, and burns with a steady light for a minute or more, according to the length of the match.

There are many arrangements for procuring light instantaneously through the united agencies of hydrogen gas and spongy platinum; but they speedily get out of order, and are but little fitted for general use.

LIGHT-HOUSES were in use with the ancients. The towers of Sestos and Abydos, the colossus of Rhodes, and the well-known tower on the island of Pharos, off Alexandria, are examples. Suetonius also mentions a lofty tower at Ostia, and another on the coast of Batavia, erected for the purpose of guiding the mariner by their light. In lighting a great extent of coast, it becomes necessary to provide for the distribution of the light-houses in such a manner that they may be readily distinguished from each other, and at the same time so disposed as not to leave vessels without some point by which to direct their course; and, in constructing each member of the series, care should be taken to provide for a sufficient brilliancy of light. One of the most extraordinary light-houses on our iron-bound coast stands on a reef of rocks, called the Eddystone, in the English Channel, about ten miles from the Ram Head in Cornwall. It was erected by Mr. Smeaton in 1759, and still remains a lasting monument of his scientific skill. It consists of four rooms, surmounted by a gallery and lantern. The floors are of stone, flat on the surface, but concave beneath, and are kept from pressing against the sides of the building by means of a chain which is let into the walls. The entire edifice is about eighty feet in height, and yet such is the immense power of the wind, in the neighbourhood of the rock, that the waves are seen to ascend like a cupola considerably above the lantern at top. The appearance of the light-house, when thus exposed to the violence of the stormy ocean, is well given in the accompanying engraving.



The *Bell Rock* light-house must now be noticed. It stands on the coast of Scotland, near Arbroath, in Forfarshire. To enable our readers to form some estimate of the difficulty attendant on the erection of this building, it may be enough to state that, during the lapse of twelve months, only forty-one hours offered in which the workmen could be employed on the rock. In the succeeding year (1814), fifty-three hours of labour occurred on the rock. In the third season, this was nearly doubled; but the operations of the fourth season were much retarded by several untoward accidents. In particular a heavy gale overtook the workmen while they were laying the seventh course of masonry, which obliged them to leave the rock before the necessary precautionary measures could be taken for closing and completing the work in hand, in consequence of which the stones on the eastern or weather side of this course were lifted off their bases, the oaken trenails broken, and five of the blocks of stone swept away. At another period, the Puzzolano mortar connecting the beds of two of the stones was washed out, and so much injured that the stones required to be lifted

and relaid. The works were this season intended to have been closed early in the month of October, when another unlucky gale sprung up, just as the sixteenth course had been laid, which raised seven more of the stones from their beds; but they were fortunately held by the oaken trenails, and in this state they remained for about three weeks, before a landing could possibly be effected to replace them.

There was one moment of appalling danger, during the progress of the work, which must not be passed unnoticed. On the 2nd of September, there were thirty-two persons upon the rock, and, while all the artificers were engaged in their several avocations, a gale arose, which carried the large vessel (the Smeaton) in which the workmen were usually conveyed ashore more than three miles to leeward of the rock. In this critical situation, placed upon an insulated rock, far out in the ocean, which in the progress of the flood-tide was to be laid under water to the depth of at least twelve feet in a stormy sea, the feelings of Mr. Stevenson, the engineer, may be better conceived than described. There were at this period only two boats attached to the rock, whose complement, even in good weather, did not exceed twenty-four sitters; but to row to the floating-light, with so much wind, and so heavy a sea, a complement of eight men for each boat was as much as could possibly be attempted, so that, in this way, about one-half of those employed on the rock must be left unprovided for. Under these circumstances, had Mr. Stevenson ventured to despatch one of the boats, in expectation of either working the Smeaton sooner up towards the rock or in hopes of getting her boat brought to the assistance of the rest, this must have given an immediate alarm to the artificers, each of whom would have insisted upon taking to his own boat, and leaving the eight artificers belonging to the Smeaton to their chance.

The unfortunate circumstance of the Smeaton and her boat having drifted was, for a considerable time, known only to Mr. Stevenson and to the landing-master, who removed to the further part of the rock, where he kept his eye steadily upon the progress of the vessel. While the artificers were at work, chiefly in sitting and kneeling postures, excavating the rock or boring with the tools, and while their numerous hammers and the sound of the smiths' anvil continued, the situation of things did not appear so awful. In this state of suspense, with almost certain destruction at hand, the water began to rise upon those who were at work on the lower parts of the sites of the beacon and light-house. From the ruff of sea upon the rock, the forge fire was sooner extinguished than usual, and, the volumes of smoke having ceased, objects in every direction became visible from all parts of the rock. After having had about three hours' work, the men began, pretty generally, to make towards their respective boats for their jackets and stockings, when, to their astonishment, instead of three they found only two boats, the third being adrift with the Smeaton. Not a word was uttered by any one, but all appeared to be silently calculating their numbers, and looking to each other with evident marks of perplexity depicted on their countenances. The landing-master, conceiving blame might be attached to him for allowing the boat to leave the rock, still kept at a distance. At this critical moment Mr. Stevenson was standing upon an elevated part of the rock, where he endeavoured to mark the progress of the Smeaton, not a little surprised that her crew did not cut the praam adrift, which greatly retarded her way. The workmen looked steadfastly at their leader, and turned occasionally towards the vessel, still far to leeward.

All this passed with the most perfect silence, and the melancholy solemnity of the group was such that, Mr. Stevenson states, it left an impression never to be effaced from his mind.

Mr. S. was, in the mean time, considering of various schemes which might be put in practice for the general safety of the party, in hopes that the Smeaton might be able to pick up the boats to leeward, when they were obliged to leave the rock. He was, accordingly, about to address the artificers on the perilous nature of their situation, and to propose that all hands should unstrip their upper clothing, when the higher parts of the rocks were laid under water,—that the seamen should remove every unnecessary weight and incumbrance from the boats, and a specified number of men should go into each boat,—and that the remainder should hang by the gunwales, while the boats were to be rowed gently towards the Smeaton, as the course of the Pharos or floating light lay rather to windward of the rock. But, when he attempted to speak, his mouth was so parched that his tongue refused utterance, and he says, "I now learned by experience that the saliva is as necessary as the tongue itself for speech." He then turned to one of the pools on the rock and drank a little salt water, which produced immediate relief; and his delight was in no small degree increased, when, on rising from this unpleasant beverage, some one called out "a boat! a boat!" and on looking round, at no great distance, a large boat was seen through the haze making towards the rock.

The stormy elements which surround this isolated station appear occasionally to excite the keenest fears in the minds of those who reside in the building; and although the compact erection of iron and masonry which they inhabit may for centuries bid defiance to the "northern blasts," or the "sulphureous bolts of heaven," yet it must require no small share of mental courage to resist the effect of such a combination of terrors.

Mr. Stevenson says, "I often take pleasure in looking at the seas breaking upon the light-house; and it is awfully grand at the time of high-water to observe the sprays rising to such a height on the building, and even to be on the rock at low-water, when the waves are about to break. Being in a manner only a few yards distant, they approach as if they were about to overwhelm us altogether. But, now that we are accustomed to such scenes, we think little of it. You will perhaps form a better idea of the force of the sea during these gales, when I relate to you that, on the 15th of February, the large piece of lead that was used as the back weight of the balance-crane, weighing 4 cwt. 3 qrs. 17 lbs., or nearly a quarter of a ton, was fairly lifted by the sea, and carried to the distance of six feet from the hole in which it had laid since the month of August. It was found turned round, with the ring-bolt downwards and it was with great difficulty that four of us could muster strength enough to return it to its former shelf in the rock.

"All the observations which I have made regarding the effects of the seas and weather on the light-house, while I have been here, lead me to conclude that when the wind is from the south, south-west, west,

north-west, and even north, the sea has little effect on the building; but, from south to north-easterly, the force of the waves is considerable, especially when it comes to blow hard. During the gale of the 22nd of February, I remarked that even the heaviest seas, if they broke before they came to the foot of the building, slipped past without giving the least shock to the house; and it is only a very few of the waves that reach the building in the course of a tide which cause the vibration alluded to; but we fear those seas only which come from the north-east, as they break close upon the house. I may say, in general, that the higher or stronger the wind, the less power the sea has on the light-house, the heaviest seas being accompanied with little wind, or occurring after the gale has abated.

"With regard to the comfort of this building as a dwelling, I had no other expectation but that, on account of the sea-air and newness of the walls, the house would have, in the first instance, been damp. It is however the very reverse of this; and I may confidently say that this is as dry round the inside walls, and on the floors, as any house in Edinburgh."

The domestic life of those who sojourn on the rock is worthy of notice. The following is a diary of their monotonous day, which commences by cleaning and trimming the lamps. This is usually succeeded by a walk on the waggon-ways, and an active search about the crevices of the rock for small fish, when the state of the tides and weather permit, but, when this is not the case, they find amusement in reading in a small library. On Sunday, those on the rock attend to the general rule of the service, doing no more work in the light-room than is necessary, cleaning only the reflectors, lamp-glasses, and windows, operations which are usually over in the summer season about twelve o'clock, after which they meet for prayers, and read two or three chapters in the Bible.

The best-constructed light-houses, in Great Britain, are fitted up with parabolic reflectors, consisting of a circular sheet of copper, plated with silver, in the proportion of six ounces to each pound of copper, and formed into a parabolic curve, by the assistance of a gauge, by a very nice process of hammering. The reflector, thus shaped, is then polished with the hand. An Argand lamp is placed in the focus of the paraboloidal surface, and the oil is supplied by the lamp behind. But the disadvantages of this mode are acknowledged; such as the loss of light, partly from its absorption by the reflector, and partly from the collision of the rays; the impossibility of increasing the intensity of the light in dark and hazy weather; the difficulty of forming distinguishing lights, &c. The important invention of the polyzonal lenses, in which refraction is employed instead of reflection, seems, therefore, likely to supersede the use of reflectors. Another important problem is the construction of distinguishing lights, so that the mariner may not be deceived in taking one light-house for another. Single and double stationary lights, or lights disposed in different forms, were first employed; revolving lights were next adopted, which appeared and disappeared at intervals; and these are sometimes exhibited double or triple. The lights may be so disposed as to illuminate only the safe channel. Difference of colour is sometimes made use of as a distinction. It sometimes becomes desirable, as in hazy weather, to produce a very intense light. A plan was proposed by Lieutenant Drummond to effect this object, by directing a stream of oxy-hydrogen gas upon a ball of lime, a quarter of an inch in diameter.

LIGHTNING. In our article ELECTRICITY the reader will find a series of experimental illustrations tending to prove the identity of lightning with electricity; and we now purpose furnishing a brief abstract of the labours of those men of science who succeeded the distinguished electrician by whom the public attention was first called to the subject. The earliest useful observations that were made on the electrical state of the atmosphere in Europe appear to have been those of Monnier; his experiments were performed with an apparatus which consisted of a pole, thirty-two feet in height, insulated in a piece of turf, having at its top a strong glass tube, to which a tube of tinned iron was attached, and which terminated in a point. About the middle of this tube there was fastened a fine iron wire, about fifty lines long, which, without touching any other body, was connected with a silk cord stretched horizontally. He found that, although the atmosphere was constantly electrified more or less, yet in dry weather the electricity increased from sunrise, when it was weakest, till about four o'clock in the afternoon, at which time it was strongest, gradually diminishing from that time till the dew began to fall, after which it diminished till midnight.

The Abbé Mazeas made several observations with an atmospherical apparatus consisting of an iron wire, 370 feet long, raised about ninety feet from the ground, and properly insulated. The results of his experiments with this instrument were the following:—In very dry weather the wire readily attracted light bodies, if brought within three or four lines of it; and, if the weather was not stormy, the electricity of the air was about half as great as that of a stick of sealing-wax two inches long. When he grasped the wire in his hand, the signs of electricity disappeared entirely, and did not return till after an interval of three or four minutes. He also found that the electricity of the atmosphere was not increased with storms and hurricanes unattended with rain; for during a violent storm of wind, which continued uninterruptedly for three days, in the month of July, he found it necessary to place the dust within four or five lines of the conductor, before it exhibited a sensible attraction. No change was produced by the different directions of the winds. In the driest nights of summer he never could observe any electricity in the air, but it began to appear in the morning at sunrise, and vanished in the evening at about half an hour after sunset. In the month of July, on a very dry day, when the sky was serene and the heat intense, he found the electricity stronger than he had ever observed it before: the dust was then attracted at the distance of ten or twelve lines from the conductor.

Having thus briefly noticed the effects of metallic rods for conveying the electricity of the atmosphere to the earth's surface, it may now be advisable to advert to another agent, which, although somewhat more complicated than the conducting wire, was yet found, in the hands of Dr. Franklin, a most efficient piece of apparatus. It consists in the elevation of a long conducting string by means of a windsail or kite.

An *electrical kite* should be constructed in the most simple manner, as it is an apparatus very liable to be injured or lost. In dimensions it should

not exceed four feet in height, by two feet wide. This will be found the most manageable size, and it is necessary to varnish it with drying oil to defend it from the rain. The string must be furnished with a thin copper or silver thread, interwoven through its whole length; that which is employed in the fabrication of gilt lace appears best adapted to the purpose. When the kite is raised, the string is insulated by attaching to it a silk cord, the opposite extremity of which may be fastened to a rail, or any other fixed place. The end of the metallic string may then be connected with a prime conductor, similar to that employed in the common electrical machine; and with this the experiments may be performed.

To ensure the safety of the operator, which is a very important consideration in this otherwise dangerous experiment, it will only be necessary to connect a brass rod with the earth, and bring the other end within about two inches of the prime conductor, so that, in the event of the kite coming in contact with a large electrical cloud, a ready passage may thus be found for the electric fluid to the earth. In raising or lowering the kite, shocks are frequently taken: this, however, may be effectually prevented by suffering a part of the string between the operator and the kite to bear constantly against the brass ball that is connected with the ground; and this precaution is more particularly essential when thunder-clouds are over-head.

Mr. Cavallo, from a variety of experiments made with electrical kites, furnishes the following results, which will be found correct in the generality of cases. "The air appears to be electrified at all times: its electricity is constantly positive, and much stronger in frosty than in warm weather; but it is by no means less in the night than in the daytime. When it rains, the electricity of the kite is generally negative, and very seldom positive. The aurora borealis seems not to affect the electricity of the kite. The electric spark taken from the string of the kite, or from any insulated conductor connected with it, especially when it does not rain, is very seldom longer than a quarter of an inch; but it is exceedingly pungent. When the index of the electrometer is not higher than 20°, the person who takes the spark will feel the effect of it in his legs, as it appears more like the discharge of an electric jar than the spark taken from the prime conductor of an electrical machine. The electricity of the kite is generally stronger or weaker, according as the string is longer or shorter; but it does not keep any exact proportion to it. The electricity, for instance, brought down by a string of 100 yards, may raise the index of the electrometer to twenty; when, with double that length, the index of the electrometer will not go higher than twenty-five."

The phenomena incident to a thunder-storm are always beheld with the most intense interest by the student in this science; and, although many very poetical descriptions of its effects are on record, the facts furnished by the Italian philosopher Beccaria are as illustrative as any.

"Thunder-storms," says Beccaria, "generally happen when there is little or no wind; and their first appearance is marked by one dense cloud, or more, increasing very fast in size, and rising into the higher regions of the air; the lower surface black, and nearly level, but the upper finely arched, and well defined. Many of these clouds seem frequently piled one upon another, all arched in the same manner; but they keep continually uniting, swelling, and extending their arches.

"At the time of the rising of this cloud, the atmosphere is generally full of a great number of separate clouds, motionless, and of odd and whimsical shapes. All these, upon the appearance of the thunder-cloud, begin to move towards it, and become more uniform in their shapes as they approach; till, coming very near the thunder-cloud, they mutually stretch towards one another, immediately coalesce, and together make one uniform mass. But sometimes the thunder-cloud will swell and increase very fast without the conjunction of these adventitious clouds, the vapours of the atmosphere forming themselves into clouds wherever it passes. Some of the adventitious clouds appear like white fringes at the skirts of the thunder-cloud, but these are continually growing darker and darker as they approach or unite with it.

"When the thunder-cloud is grown to a great size, its lower surface is often ragged, particular parts being detached towards the earth, but still connected with the rest. Sometimes the lower surface swells into various large protuberances, bending uniformly towards the earth. When the eye is under the thunder-cloud, after it is grown larger, and well formed, it is seen to sink lower, and to darken prodigiously, at the same time that a number of adventitious clouds (the origin of which can never be perceived) are seen in rapid motion, driving about in every direction under it. While these clouds are agitated with the most rapid motions, the rain generally falls in the greatest plenty; and, if the agitation is exceedingly great, it commonly hails."

While the thunder-cloud is swelling, and extending its branches over a large tract of country, the lightning is seen to dart from one part of it to another, and often to illuminate its whole mass. When the cloud has acquired a sufficient extent, the lightning strikes between the cloud and the earth, in two opposite places, the path of the lightning lying through the whole body of the cloud and its branches.

The electrical explosion generally takes place in the air, and at a considerable height; but in many instances it happens between the clouds and the earth. In most instances, perhaps, the lightning descends from the clouds to the earth, and the explosion is then called the descending stroke; but in some cases it is known to pass from the earth to the clouds, and is then termed the ascending stroke: of the latter kind appears to have been the explosion which took place on the Malvern Hills, in the summer of 1826, and which was attended with such melancholy consequences. A very curious instance of the ascending stroke is related by G. F. Richter, in his work on thunder. He informs us that in the cellar belonging to the Benedictine monks of Fontigno, while the servants were employed in pouring into a cask some wine which had been just boiled, a fine light flame appeared round the funnel, and they had scarcely finished their operation when a noise like thunder was heard; the cellar was instantly filled with fire; the cask was burst open, although hooped with iron; the staves were thrown with prodigious violence against the wall; and, on examination, a hole of three inches in diameter was found in the bottom of the cask.

LIMB; the outermost border or graduated edge of a quadrant, astrolabe, or such like mathematical instrument. The word is also used for the arch of the primitive circle, in any projection of the sphere *in plano*.

Limb also signifies the outermost border or edge of the sun and moon; as the upper limb or edge, the lower limb, &c.

LIME. This earth, well known in its most important properties from the remotest antiquity, exists in great abundance in nature. In treating of it in the present article, we shall confine ourselves to its chemical properties and its application to domestic purposes. Lime is obtained with most facility from the native carbonate, from which, by a strong heat, the carbonic acid may be expelled. This process is conducted on a large scale with the different varieties of limestone, which are calcined or burnt, in order to obtain the caustic earth, or *quicklime*, as it is called. The lime thus obtained, however, is rarely pure enough for chemical purposes. The chemist, therefore, when he would obtain a very perfect article, calcines transparent crystals of carbonate of lime, or prepares it from solution, in the following manner:—Marble or chalk is dissolved in diluted muriatic acid, leaving an excess of lime undissolved; ammonia is added, which precipitates any alumine or magnesia. The filtered solution is then decomposed by carbonate of potash, and the carbonate of lime, being washed with water and dried, is decomposed by a strong heat. The lime thus obtained is a soft white substance, of the specific gravity of 2.3. It requires an intense degree of heat for its fusion, which is effected only by the galvanic current, by the compound blowpipe, or by a stream of oxygen gas, directed through the flame of an alcohol lamp. The light it emits, during fusion, is the strongest the chemist can produce; and it has, accordingly, been employed for a signal light and for facilitating the observation of distant stations, in geodetical operations. Its taste is caustic, astringent, and alkaline. It is soluble in 450 parts of water, according to Sir H. Davy; and in 760 parts, according to other chemists. The solubility is not increased by heat. If a little water only is sprinkled on new-burnt lime, it is rapidly absorbed, with the evolution of much heat and vapour. This constitutes the phenomenon of slaking. The heat proceeds from the consolidation of the liquid water into the lime, forming a *hydrate*, as slaked lime is now called. It is a compound of 3.5 parts of lime with 1.25 of water, or very nearly 3 to 1. The water may be expelled by a red heat.

Lime-water is astringent and somewhat acrid to the taste. It renders vegetable blues green; the yellow, brown; and restores to reddened litmus its usual purple colour. When lime-water stands exposed to the air, it gradually attracts carbonic acid, and becomes an insoluble carbonate, while the water remains pure. If lime-water be placed in a capsule under an exhausted receiver, which also encloses a saucer of concentrated sulphuric acid, the water will be gradually withdrawn from the lime, which will concrete into small six-sided prisms. Lime, submitted to the action of galvanism, in high intensity, afforded Sir H. Davy satisfactory evidence of its compound nature. It was discovered, in common with the other earths, to consist of a metallic base (which he denominated *calcium*) and oxygen. The calcium was obtained, in these experiments, in the state of amalgamation with mercury. On exposing the amalgam to the air or to water, oxygen was absorbed, and lime reproduced. In an experiment designed to obtain the base in an insulated state, by distilling the quicksilver from it, the tube broke while warm, and, at the moment that the air entered, the metal, which had the colour and lustre of silver, took fire, and burnt with an intense white light. It used to be supposed that lime combined with sulphur and with phosphorus; but it rather appears that it is its base only that unites with these inflammables. The sulphuret of calcium is formed by heating sulphur with lime in a covered crucible. It is of a reddish-yellow colour. When thrown into water, mutual decomposition takes place, and a sulphuretted hydro-sulphuret, of a yellow colour, with a fetid odour, is produced. Phosphuret of calcium, or phosphuret of lime, as it has usually been called, is obtained in the following manner:—A few pieces of phosphorus are placed at the bottom of a glass tube, which is then filled with small pieces of lime. The part of the tube where the lime is is heated red-hot; and the phosphorus is then sublimed by heat. Its vapour, passing over the lime, decomposes it, and a reddish-coloured phosphuret of calcium is formed. This substance is remarkable for decomposing water, whenever it is dropped into it, and causing an immediate production of phosphuretted hydrogen, which takes fire at the surface of the water.

When lime is heated strongly in contact with chlorine, oxygen is expelled, and the chlorine is absorbed. For every two parts in volume of chlorine that disappear, one of the oxygen is obtained. When liquid muriate of lime is evaporated to dryness, and ignited, it forms the same substance, which is the chloride of calcium. It is a semi-transparent crystalline substance; fusible at a strong red heat; a non-conductor of electricity; has a very bitter taste; rapidly absorbs water from the atmosphere, and is hence often employed, in chemical experiments, to deprive gases of any hygrometric vapour existing in them. Chlorine also combines directly with lime, forming the very important substance used in bleaching, formerly known under the name of *oxymuriate of lime*, but at present, and more correctly, called *chloride of lime*. It is formed by passing chlorine gas over slaked lime.

A great variety of apparatus has been, at different times, contrived for favouring the combination of chlorine with slaked lime, for the purposes of commerce. In the opinion of Doctor Ure, who has given particular attention to this manufacture, the following construction for subjecting lime-powder to chlorine is the best:—It consists of a large chamber, eight or nine feet high, built of silicious sandstone, having the joints of the masonry secured with a cement composed of pitch, resin, and dry gypsum, in equal parts. A door is fitted into it at one end, which can be made air-tight by strips of cloth and clay-lute. A window in each side enables the operator to judge how the impregnation goes on, by the colour of the air, and also gives light for making the arrangements within at the commencement of the process. As water-lutes are incomparably superior to all others, where the pneumatic pressure is small, a large valve, or door, on this principle, is recommended to be made in the roof, and two tunnels, of considerable width, at the bottom of each side wall. The apartment would thus be ventilated, without the necessity of the workmen approaching the deleterious gas. A great number of wooden

shelves, or rather trays, eight or ten feet long, two feet broad, and one inch deep, are provided to receive the sifted slaked lime, containing generally about two atoms of lime to three of water. These shelves are piled one over another in the chamber, to the height of five or six feet, cross-bars below each keeping them about an inch asunder, that the gas may have free room to circulate over the surface of the powder. The alembics for generating the chlorine, which are usually nearly spherical, are in some cases made entirely of lead; in others, of two hemispheres, joined together in the middle, the upper hemisphere being lead, the under one cast-iron. The first kind of alembic is enclosed, for two-thirds from its bottom, in a leaden or iron case, the interval of two inches between the two being destined to receive steam from an adjoining boiler. Those which consist below of cast-iron have their bottom directly exposed to a very gentle fire. Round the outer edge of the iron hemisphere a groove is cast, into which the under edge of the leaden hemisphere fits, the joint being rendered air-tight by Roman or patent cement—a mixture of lime, clay, and oxide of iron, separately calcined and reduced to a fine powder. It must be kept in close vessels, and mixed with the requisite water when used. In this leaden dome there are four apertures, each secured by a water-lute. The first opening is about ten or twelve inches square, and is shut with a leaden valve, with incurvated edges, that fit in the water-channel, at the margin of the hole. It is destined for the admission of a workman to rectify any derangement in the apparatus of rotation, or to detach hard concretions of salt from the bottom. The second aperture is in the centre of the top. Here a tube of lead is fixed, which descends nearly to the bottom, and down through which the vertical axis passes, to whose lower end the cross-bars of iron or of wood, sheathed with lead, are attached, by whose revolution the materials receive the proper agitation for mixing the dense manganese with the sulphuric acid and salt. The motion is communicated either by the hand of a workman, applied from time to time to a winch at top, or it is given by connecting the axis with wheel-work, impelled by a stream of water or a steam-engine. The third opening admits the siphon-formed funnel, through which the sulphuric acid is introduced; and the fourth is the orifice of th eduction pipe.

The proportion of the materials for generating the chlorine is as follows: 10 cwt. of salt are mixed with from 10 to 14 cwt. of manganese; to which mixture, after its introduction into the alembic, from 12 to 14 cwt. of sulphuric acid are added in successive portions: that quantity of acid must, however, be previously diluted with water, till its specific gravity becomes about 1.65. The eduction pipes from all the alembics terminate in a leaden chest, or cylinder, with which they are connected by water-lutes, having a hydrostatic pressure of two or three inches. In this general *diversorium*, the chlorine is washed from adhering muriatic acid, by passing through a little water; and, from this reservoir, the gas is conducted off by one general pipe, and delivered into the top of the chamber containing the lime, where, in consequence of its gravity, it diffuses itself equally over powder spread out upon the shelves. Four days are required for making good marketable bleaching-powder.

The manufacturer generally expects from a ton of rock salt, employed as above, a ton and a half of good bleaching powder. In using the chloride of lime for bleaching, the coloured cloth is first steeped in warm water to clean it, and it is then repeatedly washed with a solution of caustic potash, so diluted that it cannot injure the texture of the cloth, and which solution is thrown upon it by a pump. The cloth is then washed and steeped in a very weak solution of the bleaching-powder; again washed, acted on by a boiling ley, as before, and again steeped in the solution; and these operations are performed alternately several times. The cloth is, lastly, immersed in very dilute sulphuric acid, which gives it a pure white colour, after which it is washed and dried. The chlorine is known to decompose water, whose hydrogen forms with it muriatic acid, which is always found in the solution (after the process) when liquid chlorine is used, and a muriate, when a chloride is employed. In a similar manner it is believed to decompose the colouring matter, one of whose elements is always hydrogen; and, its composition being thus subverted, it disappears from the fabric with which it existed.

Still more important is the use of the chloride of lime in counteracting contagion, and all noxious effluvia. MM. Orfila, Lescure, Gerdy, and Hennelle, having to examine the body of an individual who was supposed to have been poisoned, and who had been dead for nearly a month, found the smell so insupportable that they were induced to try the application of the chloride of lime, as recommended by M. Labarraque. A solution of this substance was frequently sprinkled over the body, and produced the effect of destroying, after a few aspersions, every unpleasant odour. It was afterwards used in a still more desperate case, in clearing some offensive drains in Paris, with perfect success. It was also found to be the best and most durable means of disinfecting hospitals, &c. In such cases, the powder is so exposed to the infected region as to offer the greatest amount of surface, in order that the carbonic acid of the contagious atmosphere may expel the chlorine from the chloride of lime, which it does by combining with it to form carbonate of lime. A very convenient method of applying it to ordinary apartments, which we are desirous to free from unwholesome effluvia, is to diffuse about four ounces of the powder through five gallons of water, and sprinkle it over the floor by means of a water-pot. Lime combines with the acids, neutralizing the acid properties. Its salts are, in general, decomposed by potash or soda, which precipitate the lime, but not by ammonia. Oxalic acid throws down lime from all the other acids; and, this compound being quite insoluble, oxalic acid forms the most delicate test of the presence of lime.

Carbonate of lime may be formed by adding carbonic acid to lime-water, or by decomposing any of the soluble salts of lime by any of the alkaline carbonates. It is very sparingly soluble in water. Hence lime-water is an excellent test of the presence of carbonic acid. By an excess of carbonic acid, carbonate of lime is rendered soluble. When exposed to heat, it first loses what water it contains, and, if transparent and hard, becomes white, opaque, and friable. If the heat is augmented, the carbonic acid gas is expelled, and quicklime remains. The experiments of Sir J. Hall have proved that if carbonate of lime be heated under strong pressure, so as to prevent the

escape of the carbonic acid, it may be melted at a temperature even not higher than 22° of Wedgwood's scale. By this fusion, it acquires considerable hardness and closeness of texture, approaching, in these qualities, as well as in fracture and specific gravity, to the finer kinds of marble. The acids expel the carbonic acid with effervescence; and this property of effervescing strongly, on the contact of an acid, affords a discriminating character of this salt. Carbonate of lime abounds in nature.

Nitrate of lime may be formed by dissolving lime, or its carbonate, in dilute nitric acid. The solution, on evaporation, affords deliquescent prismatic crystals, soluble in less than an equal weight of water, at the temperature of 60°, and in still less of boiling water. On being heated, it becomes phosphorescent, and retains this property when cold, forming *Baldwin's solar phosphorus*. It forms naturally in the plaster of old buildings, and in the limestone caverns of the Western States of America. *Sulphate* of lime is formed by adding lime to dilute sulphuric acid. It requires about 500 times its weight of water, at 60°, for its solution. At the temperature of 212°, it is more soluble, and this latter solution, on cooling, deposits minute crystals. Exposed to heat, it appears to effervesce, or boil, owing to the expulsion of its water; and, at the same time, becomes opaque, and falls into a white powder, which, on being diffused in water, speedily consolidates, forming a species of irregular crystallization. Sulphate of lime is one of the most abundant minerals in nature. *Phosphate* of lime may be formed by decomposing the solution of an alkaline phosphate by muriate of lime. It is a white insoluble powder, which is imperfectly vitrified by a very intense heat. It exists in the mineral kingdom, under different forms, and constitutes eighty-six per cent. of the bones of animals. *Muriate* of lime is obtained by dissolving carbonate of lime in muriatic acid. It is extremely soluble in water, the water taking up so much of it as to become of a thick consistence.

Lime, in *agriculture*. Quicklime, in its pure state, whether in powder or dissolved in water, is injurious to plants. Grass is killed by watering it with lime-water. But lime, in its state of combination with carbonic acid, is a useful ingredient in soils. When lime, whether freshly burnt or slaked, is mixed with any moist, fibrous, vegetable matter, there is a strong action between the lime and the vegetable matter, and they form a kind of compost together, of which a part is usually soluble in water. By this means matter which was before comparatively inert becomes nutritive; and, as charcoal and oxygen abound in all vegetable matters, the lime becomes converted into a carbonate. Mild lime, powdered limestone, marls, or chalks, have no action of this kind upon vegetable matter; by their action they prevent the too rapid decomposition of substances already dissolved; but they have no tendency to form soluble matter. From these circumstances, it is obvious that the operation of quicklime and marl or chalk depends upon principles altogether different. Quicklime, in the act of becoming mild, prepares soluble out of insoluble matter. It is upon this circumstance that the operation of lime, in the preparation of wheat crops, depends, and its efficacy in fertilizing peats, and in bringing into a state of cultivation all soils abounding in hard roots, or dry fibres, or inert vegetable matter. The solution of the question whether quicklime ought to be applied to a soil depends upon the quantity of inert vegetable matter it contains. The solution of the question whether marl, mild lime, or powdered limestone, ought to be applied, depends upon the quantity of calcareous matter already in the soil. All soils are improved by mild lime, and, ultimately, by quicklime, which do not effervesce with acids; and sands are more benefited by it than clays. When a soil, deficient in calcareous matter, contains much soluble vegetable manure, the application of quicklime should always be avoided, as it either tends to decompose the soluble matters by uniting with their carbon and oxygen, so as to become mild lime, or it combines with the soluble matters, and forms compounds having less attraction for water than the pure vegetable substance. The case is the same with respect to most animal manures; but the operation of the lime is different in different cases, and depends upon the nature of the animal matter. Lime forms a kind of insoluble soap with oily matters, and then gradually decomposes them by separating from them oxygen and carbon. It combines, likewise, with the animal acids, and probably assists their decomposition by abstracting carbonaceous matter from them, combined with oxygen, and consequently it must render them less nutritive. It tends to diminish, likewise, the nutritive powers of albumen, from the same causes, and always destroys, to a certain extent, the efficacy of animal manures, either by combining with certain of their elements or by giving to them new arrangements. Lime should never be applied with animal manures, unless they are too rich, or for the purpose of preventing noxious effluvia. It is injurious when mixed with any common dung, tending to render the extractive matter insoluble. In those cases in which fermentation is useful to produce nutriment from vegetable substances, lime is always efficacious, as with tanners' bark. Lime is much used by tanners, skinners, &c., in the preparation of their leather; by soap-boilers, for dissolving the oil, and facilitating its union with the alkaline salt; and by sugar-bakers, for refining their sugar. It is also of some medicinal use, being applied externally in desiccative and epulotic medicines.

Limit, in a restrained sense, is used by mathematicians for a determinate quantity, to which a variable one continually approaches; in which sense the circle may be said to be the *limit* of its circumscribed and inscribed polygons.

In *algebra*, the term *limit* is applied to two quantities, one of which is greater, and the other less, than another quantity; and in this sense it is used in speaking of the limits of equations, whereby their solution is much facilitated.

Limning, from *enluminer* (French); to adorn books with paintings. As these paintings or illuminations were always executed in water-colours, *limning* properly designates that species of art which is now known by the name of *miniature painting*, though it is sometimes used to signify the art of painting generally, and particularly portrait painting.

Line, in *mathematics*, is extension in length, without breadth or thickness; it is either straight or curved. In *navigation*, the equator is called the *line*; hence the expression "to pass the line." In decimal measures of length, it is the tenth; in duodecimal measures of length it is the twelfth part of an inch.

In *military affairs*, a series of soldiers or ships, drawn up in order of battle, are called a *line*; hence the phrase "ships of the line."

LINEN; a cloth of very extensive use, made of flax, and differing from cloths made of hemp only in fineness. In common linen, the warp and woof cross each other at right angles; if figures are woven in, it is called *damask*. The species of goods which come under the denomination of linen are table-cloths, plain and damasked, cambric, lawn, shirting, sheeting, towels, Silesias, Osnaburgs, &c. The chief countries in which linens are manufactured are Great Britain, Russia, Flanders, and Holland. Immense quantities of linen are annually exported from Ireland to England, and several other parts of Europe, as well as to North and South America, the West Indies, and Africa. The flax seed is, for the greater part, procured from America; but other nations, engaged in this lucrative branch of trade, either raise their seed at home or procure it from the north of Europe. In several parts of Germany, Switzerland, Flanders, and France, linens are frequently embellished with painting; and the produce of the Irish linen manufacture is occasionally printed in the manner of calicoes. The beauty of linen consists in the evenness of the thread, its fineness and density. The last of these qualities is sometimes produced by subjecting it to rollers; hence linen with a round thread is preferred to that with a flat thread. The warp or woof is not unfrequently made of cotton yarn, which renders the cloth less durable.

Linen threads cannot be spun by the machinery used in spinning cotton and wool, on account of the length and rigidity of the fibres of the flax. The subject of spinning flax by machinery has attracted much attention, and Napoleon once offered a reward of 1,000,000 francs to the inventor of the best machine for this purpose. (See SPINNING and WEAVING.)

In a historical view, linen is interesting, as forming the dress of the Egyptian priests, who wore it at all their religious ceremonies; hence they are styled by Ovid and Juvenal "linen-wearers." From Egypt linen passed to the Romans, but not till the time of the emperors. The Roman priests also began to wear linen garments at that time. Linen was used as a material for writing, though the expression *libri lintei, carbasini*, was also applied to cotton and silk as well as linen. The Sibylline books, and the mummy bandages, covered with hieroglyphics, are proofs of this use of linen. In the middle ages, linen and woollen cloth formed the only materials for dress, and fine linen was held in very high estimation. Germany and Brabant then carried linen manufactures to the greatest perfection. Linen is necessary for the manufacture of good paper. Cotton has, of late years, taken the place of linen for many purposes, on account of its greater cheapness.

LINT, in *surgery*, is the scrapings of fine linen, used by surgeons in dressing wounds. It is made in various forms, which have different names, according to the difference of the figures. Lint, made up in an oval or orbicular form, is called a *pledgit*; if in a cylindrical form, or in the shape of a date or olive stone, it is called a *dossil*. These different forms of lint are required for many purposes; as, 1. to stop blood in fresh wounds, by filling them up before the application of a bandage; though, if scraped lint be not at hand, a piece of fine linen may be torn into small rags, and applied in the same manner: in very dangerous hemorrhages, the lint or rags should be first dipped in some styptic liquor, as alcohol or oil of turpentine, or sprinkled with some styptic powder: 2. to agglutinate or heal wounds; to which end lint is very serviceable, if spread with some digestive ointment, balsam, or vulnerary liquor: 3. in drying up wounds and ulcers, and forwarding the formation of a cicatrix: 4. in keeping the lips of wounds at a proper distance, that they may not hastily unite before the bottom is well digested and healed: 5. they are highly necessary to preserve wounds from the injuries of the air.

Surgeons of former ages used compresses of sponge, wool, feathers, or cotton, linen being less plentiful than in later times; but lint is far preferable to all these, and is, at present, universally used. Lint is now manufactured by a machine.

LIQUEUR (from the *French*); a palatable spirituous drink, composed of water, alcohol, sugar, and some aromatic infusion, extracted from fruits, seeds, &c. The great difference in the qualities of the different *liqueurs* is owing principally to a variation in the proportions of the sugar and alcohol. The French distinguish three qualities: the first are the *ratafias*, or simple *liqueurs*, in which the sugar, the alcohol, and the aromatic substance are in small quantities: such are the anise-water, *noyau*, the apricot, cherry, &c. The second are the oils, or the fine *liqueurs*, with more saccharine and spirituous matter; as the *anisetta, curaço*, &c. The third are the *creams*, or superfine *liqueurs*, such as *rosoglio, maraschino*, Dantzic water, &c. The same aromatic infusion may, therefore, give its name to *liqueurs* of different qualities, in which the materials are the same, but the proportions different: thus one proportion of ingredients gives *eau-de-noyau*; another *crême-de-noyau*, &c.

LIQUORICE. The common liquorice grows wild in the south of Europe, and is cultivated in many places, even in this country, for the sake of the root, which is much used in pharmacy, and forms a considerable article of commerce. More than 200 tons of the extract are manufactured annually in Spain, a considerable portion of which is sent to London. It is often administered medicinally, in coughs and pulmonary affections, and the aqueous infusion is a refreshing beverage. A deep, light, and sandy soil is best adapted to its culture.

LISTEL; a small square moulding, serving to crown or accompany a larger, and to separate the flutings in columns.

L'ISTESSO TEMPO, in *music*; a phrase implying that the movement before which it is placed is to be played in the same time as the previous movement.

LITHIA; the name applied by Arfwedson to an alkali discovered by him in analyzing the petalite. Lithia has since been detected in spodumene, and several kinds of mica. The best process for procuring it is the following:—One part of petalite or spodumene, in fine powder, is mixed intimately with two parts of fluor-spar, and the mixture is heated with three or four times its weight of sulphuric acid, as long as any acid vapours are disengaged. The silica of the mineral is attacked by hydrofluoric acid, and dissipated in the form of fluosilicic acid gas, while the alumina and lithia unite with sulphuric acid. After dissolving these salts in water, the solution is boiled with pure ammonia to precipitate the alumina; is filtered, evaporated to dryness, and then heated to

redness to expel the sulphate of ammonia. The residue is pure sulphate of lithia, which is dissolved in water and decomposed by acetate of barytes; and the acetate of lithia, being heated to redness, is converted into the carbonate of lithia, and, finally, this is decomposed by lime or barytes, which affords pure lithia. Its colour is white; it is not deliquescent, but absorbs carbonic acid from the air; it is very soluble in water, is acrid, caustic, and acts on colours like the other alkalies: heated with platina, it acts on the metal. It combines with the different acids, and forms salts with them, like potash and soda, though possessed of a higher neutralizing power than these alkalies. Its phosphate and carbonate are sparingly soluble; its chloride is deliquescent and soluble in alcohol, and this solution burns with a red flame. All its salts give a red colour, when heated on a platinum wire before the blow-pipe. The muriate and nitrate are deliquescent. The metallic base of lithia was evolved by Sir H. Davy, by galvanism; the metal was found to be white like sodium, and burned with bright scintillations.

Lithic Acid, in combination with potash, is obtained from human urinary calculi, by digesting them in caustic lixivium: the lithate of potash gives up the lithic acid, on being mingled with acetic acid. It has the form of white shining plates, which are denser than water; is without taste or smell, and dissolves in 1400 parts of boiling water. It reddens the infusion of litmus. The lithates are all tasteless, and very sparingly soluble in water. Lithic acid, by repeated distillations, is resolved into ammonia, nitrogen, and prussic acid.

Lithochromics; the art of painting in oil upon stone, and of taking impressions on canvass. This process, which is designed to multiply the masterpieces of painting, was invented some years ago by Malapeau, in Paris, who received a patent for his invention, and has an establishment for lithochromic productions, which have been popular in Paris since 1823. This process is a substitute for the copying of portraits; it also serves as a cheap means of ornamenting walls. This art, however, is still in its infancy, as the lithochromic paintings hitherto produced are less valuable than the poorest copies. A similar but much superior invention has been made by Sennefelder, which he calls *mosaic impression*.

Lithography; the art of taking impressions from drawings or writings on stone, without engraving. Two substances are used for drawing upon stone—lithographic chalk and lithographic ink. The former is made of 1½ oz. of soap, 2 oz. of tallow, 1½ oz. of pure white wax, 1 oz. of shell-lac, ½ oz. of lamp-black. Another receipt gives 2 oz. of soap, 5 oz. of wax, ½ oz. of tallow, and 1 oz. of lamp-black. The soap, after it has been scraped fine, is put in an iron or earthen vessel, over the fire, and, when it is melted, little pieces of wax and tallow are added; it must be stirred the whole time, and, when the heat is extreme, the contents of the vessel are to be lighted by a burning taper, the stirring being continued. After a short time, the flame is to be extinguished; and, while the mixture is boiling, the lamp-black is to be gradually added. When this is done, the mixture is taken from the fire, and poured out on an iron or stone plate, and may be made into any form desired. For lithographic ink, a great many different receipts have been given, one of the most approved of which is a composition made of equal parts of tallow, wax, shell-lac, and common soap, with about one-twentieth part of the whole of lamp-black. These materials are mixed in an iron vessel; the wax and tallow are first put in, and heated till they take fire, after which the other ingredients are successively added; the burning is allowed to continue until the composition is reduced about one-third.

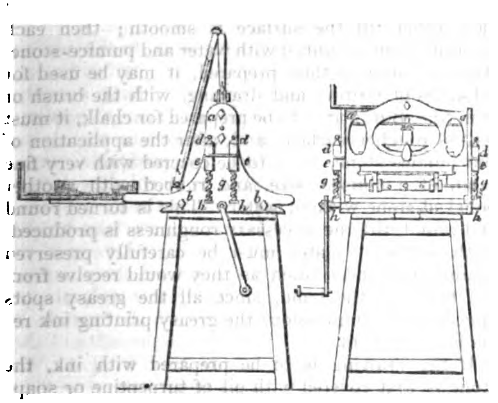
All calcareous stones, being susceptible of taking in a greasy substance, and of imbibing water with facility, are suitable for lithographic printing, provided they are compact, capable of receiving a fine polish, and of a clear and uniform colour; the more compact and uniform in colour the better. Those commonly used are a nearly pure carbonate of lime. Suitable stones are by no means scarce. The quarry from which the first lithographic stones were extracted is still that which furnishes them in the greatest abundance, and of the largest dimensions. It is situated at Solenhofen, near Pappenheim, in Bavaria. No quarries hitherto known in France afford stones equal to the German. Those found near Chateauroux are of a similar colour to those of Solenhofen, and even harder, and of a finer grain; but they are full of spots of a softer nature, so that it is difficult to procure pieces of the necessary size. In England, a stone has been used which is found at Corston, near Bath. It is one of the white lias beds, but is inferior to the German in fineness of grain and closeness of texture.

When proper stones cannot be obtained without difficulty or great expense, it is more advantageous to fabricate artificial slabs, to which a proper density and hardness may be given. An intelligent potter can easily imitate the density of natural stones. Slabs, used for this purpose, have been made of stucco, composed of lime and sand, and fastened with the caseous part of milk. Artificial slabs, however, have not been made so as to equal the real ones; and the royal institute of France have thought the subject of sufficient importance to offer a large prize for the best. The stones are polished by putting fine sand between two of them, and thus rubbing them against each other till the surface is smooth; then each separate stone is rubbed with water and pumice-stone. After the stone is thus prepared, it may be used for all kinds of writing and drawing, with the brush or pen, &c. But, if it is to be prepared for chalk, it must have a rougher surface, and, after the application of the pumice-stone, it is to be covered with very fine sand, of a uniform size, and rubbed with another polished stone without water. This is turned round and round, till the necessary roughness is produced. Both kinds of plates must be carefully preserved against greasiness, such as they would receive from the touch of the hand, since all the greasy spots appear in the impression, the greasy printing ink remaining on them.

If the drawing is to be prepared with ink, the stone is first covered with oil of turpentine or soap-water, to prevent the lines from spreading. Then the drawing may be made on the stone with a black-lead pencil or with a red crayon; but the latter is preferable, because, when the ink comes to be applied, it is easier to discover how far the lines of the drawing are really covered with ink. After having dissolved the ink in rain or river water (the former ought to have stood some time), these pencil outlines are covered with ink. If the stroke is black, or, at least, dark brown, it may be inferred that the in-

pression will succeed; but, if light brown and transparent, it will not give the impression. The ink may be laid on with the pen or brush. Goose quills, however, are not well suited for this purpose, particularly if the strokes are to be very fine; the pens are too quickly blunted; but steel pens are used with great advantage: these are made of watch springs. After the drawing, the plate is left several hours, and then put under the press. For drawing with chalk, it is necessary to apply the finest and softest tints first, and the strongest afterwards. If the proper effect cannot be given to the foreground by chalk only, a little ink is added with the brush or pen. If the drawing has very fine tints, it is necessary that the impression from the plate should be taken immediately, otherwise the oil will dry or evaporate, and the ink will not take effect on these parts. The oil varnish used must be of the best kind. Before the stone is covered with ink, it must first be dipped in nitric or sulphuric acid, diluted with water to such a degree that only a slight effervescence is produced; the proportion of acid should be but little more than one per cent.; this will make the stone in the parts not covered by the drawing more readily imbibe the water. This process is called *etching* the drawing. After this, it is merely dipped in common water. Great care must be taken that the acid is not too strong, as it will then injure the fine strokes and tints. When the stone has imbibed sufficient water, a liquid mixture must be poured over it, consisting of one-sixth linseed oil, two-sixths oil of turpentine, and three-sixths of pure water: this again must be wiped off clean, and the stone must then be covered with a solution of gum-Arabic in water; this prevents the lines from spreading. Immediately after this process it is inked. The printing-ink is applied by means of printers' balls, stuffed with hair, or by cylinders, which must be of various sizes.

The printing-press for lithographic purposes is very simple in the arrangement of its parts, which may be readily understood by reference to a diagram.



It consists of a solid table of wood, supporting two iron uprights, *b*, *b*. Between the uprights is placed a roller, *h*, and above that a blunt scraper to give the requisite pressure. The stone from which the impression is to be taken is placed on a moving platform, which passes between the roller and scraper, and, the paper being confined on the surface of the drawing, the handle is turned so that the paper is drawn under the line of pressure. The requisite amount of force is communicated by the lever *a*, and the whole regulated by the screws *d*, *e*, *g*.

The first impressions are seldom perfect. After each impression, the stone is washed with water, and, from time to time, is sponged over with gum-water, which is prepared from one ounce of finely pounded gum-Arabic and half a pound of water. The ink which has settled on a spot that should be light is either removed with a clean sponge, or by diluted acid, applied with a sponge, and the place is afterwards washed with pure water. The printing-ink is composed, like other printing-inks, of oil-varnish and fine lamp-black. To prepare the varnish, a vessel is about half filled with pure linseed oil, and heated till it takes fire from the flame of a piece of burning paper. It is allowed to burn till reduced to the proper density. Besides the mode of preparing the drawings above described, drawings are also cut into the stone, and from these impressions are taken. Engravings may also be multiplied by putting them wet on a stone, when they come from the copper-plate press, and subjecting them to pressure, by which the ink is made to leave the paper and adhere to the stone. Although lithography is of great use, and excellent impressions are produced, particularly at Munich, it is yet very imperfect. In landscapes, the soft tints and the perspective cannot be properly given; the lines are not sufficiently delicate. The number of impressions which can be taken from a lithographic chalk drawing will vary according to the fineness of the tints. A fine drawing will give 400 or 500; a strong one, 1000 or 1500. Ink drawings and writings give considerably more than copper-plates. The finest will yield 6000 or 8000, and strong lines and writings many more. Upwards of 80,000 impressions have been taken at Munich from one writing of a form for regimental returns. But the art is susceptible of further improvements.

LITHOTOMY. See STONE.

LITHOTRITIE. The stone, a disease common throughout Europe, and the most painful of all maladies, hitherto relieved only by a formidable operation, of which death was too often the result, is, by the novel process of which we are about to give an outline—a process of perfect safety and great simplicity—rendered susceptible of cure in its most advanced stages; and surgery is furnished with means of preventing its growth at an earlier period. The value of the treatment, for which we are indebted to the French, calls upon every one to assist in making known to the utmost of his power the revolution which is in progress for the relief of the greatest of human sufferings.

The Baron Heurtèloup, a French surgeon of great ingenuity and attainments, to whom the world is indebted for the perfection to which this department of his art has now arrived, has demonstrated publicly the nature and practice of this most extraordinary process, which has been named by the French faculty *lithotritie*. It consists in breaking the calculous concretions, which form within the bladder, into powder, or particles so minute that they are readily discharged by the natural passage through which the mechanism necessary for the destruction of the foreign body is introduced, without subjecting the patient to the terrors or dangers of incision. During the last seven years this process has occupied the attention of several ingenious French surgeons, amongst whose researches those of Baron Heurtèloup are the most prominent, having procured him " the grand

prize of surgery" for the year 1827 from the institute, for the perfection of the instruments he then suggested. Before his inventions, the destruction of these concretions was accomplished by repeated perforations, the result of which was their division into fragments, which fragments underwent in succession a subdivision by the same perforating instruments: but the baron saw the necessity of devising some means more rapid, and consequently less fatiguing to the organ in which they were employed; and he succeeded in obtaining them.

His instruments are introduced in a tube of small diameter, and, developing themselves in the bladder, are so adapted that the foreign body places itself within the branches which open opposite its neck, and, subsequently included within them, is retained firmly. The mechanism of this part of the apparatus, which consists of four branches, movable at will, together or separately, is peculiarly ingenious, and of very extensive application in various circumstances which may modify its use. Suffice it to say that the stone, firmly embraced by these four branches, placed in the centre of the bladder, which has been previously filled with tepid water, is submitted to the action of what the baron calls the *evideur*, by the progressive, though rapid, eccentric motion of which its interior is completely excavated; and the exterior falls into the bladder in fragments resembling portions of shell, having a convex or concave surface. For the reduction to powder of these portions, Baron Heurtèloup uses an instrument which he appropriately calls *brisecoque*, or shell-breaker. It consists of two branches, enclosed in a tube of small diameter also, which, by a very simple mechanism, extend and seize these fragments; and with extraordinary power (yet perfect protection against injury to the bladder) grind them into fine powder, which, being voided, as well as the detritus resulting from the action of the *evideur*, is passed off with the warm water previously introduced, and so terminates the operation.

We should not omit to mention an important invention auxiliary to the baron's operation—a species of bed, or great chair, on which the patient reposes, furnished with a mode of fixing the instrument (after the stone is seized), enabling the operator to dispense with the clumsy and embarrassing apparatus held by an assistant, previously in use.

Liver; a large gland which occupies a considerable portion of the cavity of the belly, and which secretes the bile. It is a single organ, of an irregular shape, brownish-red colour, and, in general, is smaller in proportion as the individual is more healthy. It occupies the right *hypochondrium*, or space included by the false ribs, and a part of the epigastric region, and lies immediately under the diaphragm (midriff), above the stomach, the transverse colon, and right kidney, in front of the vertebral column, the *aorta*, and the inferior *vena cava*, and behind the cartilaginous edge of the chest. The right false ribs are on its right, and the spleen is on its left. The superior surface is convex, and the inferior is irregularly convex and concave, which has given rise to the division into the *right* or *large* lobe, the *small* or *inferior* lobe, and the *left* lobe. The right extremity of the liver is lower than the left, and is the most bulky part of the organ. The pressure of the surrounding organs, and certain folds of *peritoneum*, called its *ligaments*, which connect it with the diaphragm, retain the liver in its place, leaving it at the same time a considerable power of changing its relative position. The organization of the liver is very complicated. Besides its peculiar tissue, or *parenchyma*, the texture of which is unknown, it receives a larger number of vessels than any other gland. A peculiar venous system—that of the *vena portarum*—is distributed in it. To this must be added the ramifications of the hepatic artery and veins, the nerves, which are small, the lymphatic vessels, the excretory tubes, and a peculiar tissue, enclosed by a double membrane, a serous or peritoneal, and a cellular one. The excretory apparatus of the bile is composed of the hepatic duct, which, rising immediately from the liver, unites with the cystic duct, which terminates in the gall-bladder. The choledochic duct is formed by the union of the two preceding, and terminates in the *duodenum*. (See Bile.)

Livre; an ancient French coin. The word is derived from the Latin *libra*, a pound. It appears as early as 810 B.C. At first the livre was divided into twenty *solidos*; afterwards into ten *sous*; in Italy into twenty *soldi*; in Spain into twenty *sueldos*, as the old German pound into twenty *schillinge*, and the English into twenty shillings. The livre was, at first, of high value. The revolution changed the name into *franc*.

Loan, Public, is the name given to money borrowed by the state. There may occur cases which require expenses for which the ordinary revenue of the state is not sufficient. If, in such cases, it is not possible to increase the usual revenue by augmenting the taxes, without great inconvenience to the nation, the state will find it advisable to borrow, and to pay interest till it can discharge the principal. If such loans are appropriated to objects by which the means of production are augmented, the state strengthened, and industry increased, they answer the same purpose as those which an industrious tradesman makes in order to enlarge and improve his business. If he be successful, he will increase his property, and the loan itself will afford the means for repaying it. This will be the case also with the state, when it employs the borrowed capital to open to the nation increased means of profitable industry, by facilitating its intercourse with other countries, giving security to its commerce, and increasing its means of production. But if the loans are expended in useless or unfortunate wars, or in other unprofitable ways, they diminish the means of labour or enjoyment, and burden the nation with taxes to pay the interest and discharge the capital. The capitalists who aid in producing, when they lend their capital to men of business, and receive their interest from the proceeds of their capitals, become unproductive subjects as soon as they lend it to the state which expends it uselessly,—for now they live on the products of the capitals of others, when before they lived on the products of their own. As loans, however, may become necessary to the state, the only question is, What is the most advantageous method of making them? A chief distinction among loans is this—that the government promises either the repayment of the capital at a particular time, until which it pays interest, or reserves the liberty to retain the capital, according to its own pleasure, only paying interest regularly. The first kind is liable to occasion trouble to the state, because the payment may often

fall at an inconvenient time. The payment of large sums, too, at a particular period, has this disadvantage, that the nation, when the payment is to be made, becomes destitute of ready money. Therefore large loans are usually contracted in such a way that the payment is made, successively, at many periods, or remains entirely indefinite. The last kind of loans requires that the credit of the state should be undoubted, and also that large capitals should have been accumulated in the hands of many rich people, who find their greatest advantage in disposing of them in loans.

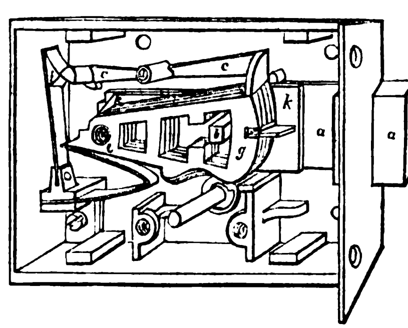
Where there is a well-founded system of credit, statesmen think it most advantageous to secure only the regular payment of the stipulated interest, but to leave the payment of the capital at the pleasure of the state. This is called the *funding system*, as far as fixed funds are assigned for the perpetual payment of the interest. These *perpetual annuities*, as they are called, had their origin in this country, but have since been imitated in Holland, France, Russia, Austria, and many other states. In order to provide for the redeeming of the capital, a sinking-fund is established, together with the fund appropriated to the payment of the annuities. This is procured by means of a tax large enough to pay the annuity as long as it lasts, and to redeem, annually, a part of the capital debt. This sinking-fund is increased every year, if the annuities annually redeemed are added to it. (See SINKING-FUND.) According to this method, the state cannot be said, properly, to borrow capital; it sells annuities, and fixes, at the sale, the rate at which they may be redeemed. They are commonly estimated at so much per cent. The government says—I offer you an annuity of three, four, five, &c., per cent., redeemable at my pleasure, How much will you give me for it? According to the market rate of interest, and the degree of credit which the state enjoys, the capitalists offer 50, 60, 70, 80, 90, &c., per cent.

The sinking-fund aims to discharge the debt gradually, by redeeming, annually, part of the annuities at the market price. If the latter exceed the price for which it had sold its annuities, it will be obliged to redeem them with loss; but, if it be less, it can redeem them with gain. Another kind of loan is when the capitalists pay 100 per cent. at a fixed rate of interest, the government reserving the right to pay the capital at any convenient time. Suppose that the state, when it wishes to borrow, is obliged to pay eight per cent., and that these stocks in the course of three years should rise in the market 100 per cent. above par; the state would easily find capitalists who would lend at the rate of four per cent. annually, and with this it could redeem the eight per cent. stocks. If, therefore, the state has reason to expect that the price of the stocks will rise, its best plan is to receive a fixed capital sum at such a rate of interest as it is obliged to give. But, if it fears that the interest or the prices of the stocks will fall, it is for its advantage to procure the necessary money by the sale of stocks at the market price, because it may hope to redeem them at a reduced rate. Sometimes premiums, or the chances of a lottery, are employed to stimulate reluctant capitalists, and sometimes even force. If a government must have recourse to other means than those arising from the annuity or interest offered, it is a certain sign that it enjoys but a feeble credit, or that there is a want of capital. How fertile modern history is in loans of every kind, and into what an unhappy situation many states have fallen by reason of them, are well known. In Austria, the proprietors of the stocks have been forced several times to advance further sums, to avoid losing what they had already lent. (See NATIONAL DEBT.)

LOCK; a well known instrument, used for fastening doors, chests, &c., generally opened by a key. The lock is reckoned the master-piece in smithery, a great deal of art and delicacy being required in contriving and varying the wards, springs, bolts, &c., and adjusting them to the places where they are to be used, and to the several occasions of using them. The principle on which all locks depend is the application of a lever to an interior bolt, by means of a communication from without, so that, by means of the latter, the lever acts upon the bolt, and moves it in such a manner as to secure the lid or door from being opened by any pull or push from without.

The security of locks, in general, therefore depends on the number of impediments we can interpose betwixt the lever (the key) and the bolt which secures the door: and these impediments are well known by the name of *wards*, the number and intricacy of which are supposed to distinguish a good lock from a bad one. If these wards, however, do not, in an effectual manner, preclude the access of all other instruments besides the proper key, it is still possible for a mechanic, of equal skill with the lock-maker, to open it without the key, and thus to elude the labour of the other. Various complicated and difficult locks have been constructed by Messrs. Bramah, Taylor, Spears, and others. In a very ingenious lock, invented by Mr. Perkins, twenty-four small blocks of metal, of different sizes, are introduced, corresponding to the letters of the alphabet. Out of these, an indefinite number of combinations may be made. The person locking the door selects and places the blocks necessary to spell a particular word, known only to himself, and no other person, even if in possession of the key, can open the door, without a knowledge of the same word.

The *detector lock*, invented by Mr. Chubb, has many advantages over those already adverted to. It is represented in the accompanying engraving.



The principal bolt is shown at *a a*, in which is placed a square pin fitting in the grooves above. The "detector," shown at *c c*, is made to move on the centre *d*, and its motions are regulated by the spring at *f*. The tumblers *g* are lifted by the key to such a position as will enable the square pin *b* of the bolt to pass in unlocking. Should one or more of the n-

blers be lifted by a "pick," or false key, in the least degree beyond their present position, the detector *c c*, being thus over-shot, will, by the angle of the spring *f* pressing on the opposite side of the angle of the detector, force its hook into a notch in the bolt, and be firmly held so until disengaged by the regulating slide *k*.

One peculiar feature in this lock arises from the great durability of its parts, which are peculiarly formed to resist any attempt at external violence; and so little is it acted on by friction that a lock of this description was actually opened and shut 460,000 times without the least apparent wear of its parts. Mr. Chubb has another arrangement of bolts for massive chests, which may be opened and shut with a handle, and yet securely fastened by a small lock on this principle.

Lock, Detonating. The employment of fulminating powder for firing the common fowling-piece has many advantages over the common flint and steel. The success of this arrangement has given it a place in his Majesty's service for firing cannon. In the latter case, the detonating powder is contained in a small paper tube, and is certain in its operation.

Locks, in *canal navigation*. When a canal changes from one level to another of different elevation, the place where the change of level takes place is commanded by a lock. Locks are tight oblong enclosures, in the bed of the canal, furnished with gates at each end, which separate the higher from the lower parts of the canal. When a boat passes up the canal, the lower gates are opened, and the boat glides into the lock, after which the lower gates are shut. A sluice, communicating with the upper part of the canal, is then opened, and the lock rapidly fills with water, elevating the boat on its surface. When the lock is filled to the highest water level, the upper gates are opened, and the boat, being now on the level of the upper part of the canal, passes on its way. A process the reverse of this is performed when the boat is descending the canal. Locks are made of stone or brick, sometimes of wood. The gates are commonly double, resembling folding doors. They meet each other, in most instances, at an obtuse angle, and the pressure of the water serves to keep them firmly in contact. Cast-iron gates are sometimes used in this country, curved in the form of a horizontal arch, with their convex side opposed to the water. In China, inclined planes are said to be used instead of locks, along which the boats are drawn up or let down.

Locomotion. The chief obstacles which oppose locomotion, or change of place, are gravity and friction, the latter of which is, in most cases, a consequence of the former. Gravity confines all terrestrial bodies against the surface of the earth, with a force proportionate to the quantity of matter which composes them. Most kinds of mechanism, both natural and artificial, which assist locomotion, are arrangements for obviating the effects of gravity and friction. Animals that walk obviate friction by substituting points of their bodies instead of large surfaces, and upon these points they turn, as upon centres, for the length of each step, raising themselves wholly or partly from the ground in successive arcs, instead of drawing themselves along the surface. As the feet move in separate lines, the body has also a lateral vibratory motion. A man in walking puts down one foot before the other is raised, but not in running. Quadrupeds, in walking, have three feet upon the ground for most of the time; in trotting, only two. Animals which walk against gravity, as the common fly, the tree-toad, &c., support themselves by suction, using cavities on the under side of their feet, which they enlarge at pleasure, till the pressure of the atmosphere causes them to adhere. In other respects their locomotion is effected like that of other walking animals. Birds perform the motion of flying by striking the air with the broad surface of their wings in a downward and backward direction, thus propelling the body upward and forward. After each stroke the wings are contracted, or slightly turned, to lessen their resistance to the atmosphere, then raised, and spread anew. The downward stroke also being more sudden than the upward is more resisted by the atmosphere. The tail of birds serves as a rudder to direct the course upward or downward. When a bird sails in the air without moving the wings, it is done in some cases by the velocity previously acquired, and an oblique direction of the wings upward; in others, by a gradual descent, with the wings slightly turned in an oblique direction downward. Fishes, in swimming forward, are propelled chiefly by strokes of the tail, the extremity of which, being bent into an oblique position, propels the body forward and laterally at the same time. The lateral motion is corrected by the next stroke, in the opposite direction, while the forward course continues. The fins serve partly to assist in swimming, but chiefly to balance the body, or keep it upright; for, the centre of gravity being nearest the back, a fish turns over when it is dead or disabled. Some other aquatic animals, as leeches, swim with a sinuous or undulating motion of the body, in which several parts at once are made to act obliquely against the water. Serpents, in like manner, advance by means of the winding or serpentine direction which they give to their bodies, and by which a succession of oblique forces are brought to act against the ground. Sir Everard Home is of opinion that serpents use their ribs in the manner of legs, and propel the body forwards by bringing the plates on the under surface of the body to act, successively, like feet against the ground. This he deduces from the anatomy of the animal, and from the movements which he perceived in suffering a large coluber to crawl over his hand. Some worms and larvæ of slow motion extend a part of their body forwards, and draw up the rest to overtake it, some performing this motion in a direct line, others in curves.

When land animals swim in water, they are supported, because their whole weight, with the lungs expanded with air, is less than that of an equal bulk of water. The head, however, or a part of it, must be kept above water, to enable the animal to breathe; and to effect this, and also to make progress in the water, the limbs are exerted, in successive impulses, against the fluid. Quadrupeds and birds swim with less effort than man, because the weight of the head, which is carried above water, is, in them, a smaller proportional part of the whole than it is in man. All animals are provided by nature with organs of locomotion best adapted to their structure and situation; and it is probable that no animal, man not excepted, can exert his strength more advantageously by any other than the natural mode, in moving himself over the common surface of the ground. Thus walking cars, velocipedes, &c., although they may enable a man to increase his velocity, in favourable situations, for a short time, yet

they actually require an increased expenditure of power, for the purpose of transporting the machine made use of, in addition to the weight of the body. When, however, a great additional load is to be transported with the body, a man or animal may derive much assistance from mechanical arrangements.

For moving weights over the common ground, with its ordinary asperities and inequalities of substance and structure, no piece of inert mechanism is so favourably adapted as the wheel-carriage. It was introduced into use in very early ages. Wheels diminish friction, and also surmount obstacles or inequalities of the road, with more advantage than bodies of any other form in their place could do. The friction is diminished by transferring it from the surface of the ground to the centre of the wheel, or, rather, to the place of contact between the axletree and the box of the wheel; so that it is lessened by the mechanical advantage of the lever, in the proportion which the diameter of the axletree bears to the diameter of the wheel. The rubbing surfaces, also, being kept polished, and coated with some unctuous substance, are in the best possible condition to resist friction. In like manner the highest ridges that present themselves in the public roads are surmounted by a wheel with peculiar facility. As soon as the wheel strikes against a stone, or similar hard body, it is converted into a lever for lifting the load over the resisting object. If an obstacle eight or ten inches in height were presented to the body of a carriage unprovided with wheels, it would stop its progress, or subject it to such violence as would endanger its safety. But, by the action of a wheel, the load is lifted, and its centre of gravity passes over in the direction of an easy arc, the obstacle furnishing the fulcrum on which the lever acts. Rollers placed under a heavy body diminish the friction in a greater degree than wheels, provided they are true spheres or cylinders, without any axis on which they are constrained to move; but a cylindrical roller occasions friction whenever its path deviates in the least from a straight line. The mechanical advantages of a wheel are proportionate to its size, and the larger it is the more effectually does it diminish the ordinary resistances. A large wheel will surmount stones and similar obstacles better than a small one, since the arm of the lever on which the force acts is longer, and the curve described by the centre of the load is the arc of a larger circle, and of course the ascent is more gradual and easy. In passing over holes, ruts, or excavations, also, a large wheel sinks less than a small one, and consequently occasions less jolting and expenditure of power. The wear also of large wheels is less than that of small ones; for, if we suppose a wheel to be three feet in diameter, it will turn round twice while one of six feet in diameter turns round once; so that its tire will come twice as often in contact with the ground, and its spokes will twice as often have to support the weight of the load. In practice, however, it is found necessary to confine the size of wheels within certain limits, partly because the materials used would make wheels of great size heavy and cumbersome, since the separate parts would necessarily be of large proportions to have the requisite strength, and partly because they would be disproportioned to the size of the animals employed in draught, and compel them to pull obliquely downwards, and therefore to expend a part of their force in acting against the ground.

Locomotive Engine is that which is calculated to produce locomotion, or motion from place to place. (See Steam-Engine.)

Log; a machine used to measure the rate of a ship's velocity through the water. For this purpose, there are several inventions, but the one most generally used is the following, called the *common log*. It is a piece of thin board, forming a quadrant of a circle of about six inches radius, and balanced by a small plate of lead, nailed on the circular part, so as to swim perpendicularly in the water, with the greater part immersed. The log-line is fastened to the log by means of two legs, one of which is knotted, through a hole at one corner, while the other is attached to a pin, fixed in a hole at the other corner, so as to draw out occasionally. The log-line, being divided into certain spaces, which are in proportion to an equal number of geographical miles as a half or quarter minute is to an hour of time, is wound about a reel. The whole is employed to measure the ship's head-way in the following manner:—The reel being held by one man, and the half-minute glass by another, the mate of the watch fixes the pin, and throws the log over the stern, which, swimming perpendicularly, feels an immediate resistance, and is considered as fixed, the line being slackened over the stern, to prevent the pin coming out. The knots are measured from a mark on the line, at the distance of twelve or fifteen fathoms from the log. The glass is therefore turned at the instant that the mark passes over the stern; and, as soon as the sand in the glass has run out, the line is stopped. The water, then being on the log, dislodges the pin, so that the board, now presenting only its edge to the water, is easily drawn aboard. The number of knots and fathoms which had run off at the expiration of the glass determines the ship's velocity. The half-minute glass, and divisions on the line, should be frequently measured, to determine any variation in either of them, and to make allowances accordingly. If the glass run thirty seconds, the distance between the knots should be fifty feet. When it runs more or less, it should therefore be corrected by the following analogy:—As thirty is to fifty so is the number of seconds of the glass to the distance between the knots upon the line. As the heat or moisture of the weather has often a considerable effect on the glass, so as to make it run slower or faster, it should be frequently tried by the vibration of a pendulum. As many accidents attend a ship during a day's sailing, such as the variableness of winds, the different quantity of sail carried, &c., it will be necessary to heave the log at every alteration, and, even if no alteration be perceptible, yet it ought to be occasionally heaved. The inventor of this simple but valuable device is not known, and no mention of it occurs till the year 1607, in an East India voyage, published by Purchas.

Log-Board; two boards shutting together like a book, and divided into several columns, containing the hours of the day and night, the direction of the winds, and the course of the ship, with all the material occurrences that happen during the twenty-four hours, or from noon to noon, together with the latitude by observation. From this table, the officers work the ship's way, and compile their journals. The whole, being written with chalk, is rubbed out every day at noon.

LOG-BOOK; a book into which the contents of the log-board are daily transcribed at noon, together with every circumstance deserving of notice that may happen to the ship, or within her cognizance, either at sea, or in a harbour, &c. The intermediate divisions or watches of a log-book, containing four hours each, are usually signed by the commanding officer thereof, in ships of war or East Indiamen.

LOGARITHM. "The logarithms of numbers are the exponents of the different powers to which a constant number must be raised in order to be equal to those numbers; the principles, therefore, which apply to exponents in general apply to logarithms." To constitute a logarithm, it is necessary that the exponent should refer to a system or series. These exponents, therefore, constitute a series of numbers in arithmetical proportion, corresponding to as many others in geometrical proportion. Take, for instance, the series $10^1 = 10$; $10^2 = 100$; $10^3 = 1000$; $10^4 = 10{,}000$: then we have the logarithm of $10 = 1$; logarithm $100 = 2$; logarithm $1000 = 3$; logarithm $10{,}000 = 4$, &c.

Perhaps the definition of a logarithm may be more scientifically expressed thus: *logarithm* is a mathematical term for a number by which the magnitude of a certain numerical ratio is expressed in reference to a fundamental ratio. The value of a ratio becomes known to us by the comparison of two numbers, and is expressed by a number called the *quotient* of the ratio; for instance, 12:4 is expressed by 3, or 18:9 by 2; 3 and 2 being called the *quotients* of the two proportions 12:4 and 18:9. If we now imagine a series of proportions which have all the same value or quotient, as, for instance, 1 to 3, 3 to 9, 9 to 27, 27 to 81, &c. (in which 9 and 3, 27 and 9, 81 and 27, are in the same ratio as 3 and 1), and if we at the same time adopt the ratio 3 to 1 as the fundamental ratio (or the unit of these ratios), then 9 to 1 is the double of this ratio, 27 to 1 the triple, 81 to 1 the quadruple, and so on. The numbers 1, 2, 3, 4, which indicate the value of such ratios in respect to the fundamental ratio, are called *logarithms*. If, therefore, in this case, 1 is the logarithm of 3, 2 must be the logarithm of 9, 3 of 27, 4 of 81, &c. If we adopt, however, the ratio of 4:1 as the fundamental one, and hence 1 as the logarithm of 4, then 2 would be the logarithm of 16, 3 of 64, &c. The logarithms of the numbers which lie between must be fractions, and are to be calculated and put in a table.

A table of logarithms, made according to an assumed basis or fundamental ratio, of all numbers to a certain limit, is called a *logarithmic system*. The most common, at present, is that of Briggs, in which the fundamental basis is 10 to 1; hence 1 is the logarithm of 10, 2 of 100, 3 of 1000, 4 of 10,000, &c. It is evident that all logarithms of numbers between 1 and 10 must be more than 0, yet less than 1, i. e. a fraction; thus the logarithm of 6 is 0.7781513. In the same way, the logarithms of the numbers between 10 and 100 must be more than 1, but less than 2, &c.; thus the logarithm of 95 is $= 1.9777236$. All logarithms of the numbers between 0, 10, 100, 1000, &c., are arranged in tables, the use of which, particularly in calculations with large numbers, is very great. The process is simple and easy. If there are numbers to be multiplied, we have only to add the logarithms; if the numbers are to be divided, the logarithms are merely to be subtracted; if numbers are to be raised to powers, their logarithms are multiplied; if roots are to be extracted, the logarithms are merely to be divided by the exponent of the root. In a table of logarithms, the integer figure is called the *index* or *characteristic*. The decimals are called, by the Germans and Italians, the *mantissa*. In general, the logarithms of the system in which 1 indicates 10 are called *common logarithms*.

The properties of logarithms, and some of their uses, were taken notice of by Stiefel or Stifelius, a German clergyman, who wrote as early as 1530; but the use of them in trigonometry was discovered by John Napier, a Scotch baron, and made known by him in a work published at Edinburgh, in 1614. Logarithmic tables are of great value, not only to mathematicians, but to all who have to make calculations with large numbers. Logarithms are of incalculable importance in trigonometry and in astronomy. Vega's edition of Vlacq's tables contains a trigonometrical table of the common logarithms of the radius or *log. sin. tot.* $= 10.0000000$, which gives the logarithms of sines, arcs, co-sines, tangents, and co-tangents for each second of the two first and two last degrees, and for each ten seconds of the rest of the quadrant. Under Napier's direction, B. Ursinius first gave the logarithm of the sines of the angles from 10 to 10″, the logarithm of the tangents, which are the differences of the logarithms of each sine and co-sine, together with the natural sine for a radius of 100,000,000 parts. Kepler turned his attention particularly to the invention of Napier, and gave a new theory and new tables. Briggs was also conspicuous in the construction of tables. Mercator showed a new way for calculating the logarithms easily and accurately. Newton, Leibnitz, Halley, Euler, L'Huillier, and others, perfected the system much, by applying to it the binomial theorem and differential calculus. The names of Vlacq, Sherwin, Gardiner, Hutton, Taylor, Callet, and others, deserve to be honourably mentioned. The edition of Vlacq, within a few years, by Vega, is particularly valuable. During the French revolution, when all measures were founded on the decimal division, new tables of the trigonometrical lines and their logarithms became necessary. The director of the *bureau du catastre*, M. Prony, was ordered, by government, to have tables calculated, which were to be not only extremely accurate, but to exceed all other tables in magnitude. This colossal work, for which the first mathematicians supplied the formulas and the methods for using the differences in the calculations, was executed, but the depreciation of the paper money prevented its publication. The tables would have occupied 1200 folio pages.

LOGGE DI RAFFAELLO. This wonderful logge has formed a school and *studio* to every artist who has visited Rome since its completion. There is scarcely a scroll ornament of any value in the works of the modern artists that may not be traced to those designed by Raphael, and executed by his pupils in this place. Leo X. had these *logge* or arcades built under the direction of Raphael. There are three stories, which enclose a court called *il Cortile di S. Damaso*. The middle story is the most celebrated. It is formed by thirteen arches, and the vault of each contains four paintings in fresco, representing scenes from the Old Testament, and executed by Giulio Romano, Pierin dal vaga, Pellegrino da Modena, Polidoro, and Maturino da Caravaggio, and others, after cartoons prepared by the great Raphael himself,

The number of these exquisite pictures is fifty-two; the arches and pilasters are adorned with grotesque paintings, executed by Giovanni da Udine, so famous in this branch, also under the direction of Raphael.

LOGWOOD. This important article of commerce is the wood of the *hæmatoxylon Campechianum*, a small straggling tree, belonging to the family *leguminosæ*, which grows wild in moist places, along the western shores of the gulf of Mexico. The wood is red, tinged with orange and black, so heavy as to sink in water, and susceptible of receiving a good polish; but it is chiefly employed in dyeing. The black and purple colours are very much used, but they are not so permanent as some obtained from other substances. Though cultivated to some extent in Jamaica, the logwood of commerce is chiefly obtained from Honduras, where the cutting of it forms an extensive, but unhealthy, branch of business.

LOMBARD HOUSES. See PAWNBROKERS.

LONGEVITY. The extreme limit of human life, and the means of attaining it, have been a subject of general interest, both in ancient and modern times, and the physiologist and political economist are alike attracted by the enquiry. It is for the student of biblical antiquities to decide in what sense we are to understand the word *year* in the scriptural accounts of the antediluvians; whether it signifies a revolution of the sun or of the moon, and, if the former, whether their extreme longevity is to be traced to supernatural causes. According to the sense which we now give to the word *year*, the constitution of men at the period referred to must have been very different from what it is at present, or has been at any period from which observations on the duration of human life have been transmitted to us. The results of all these observations, in regard to the length of life in given circumstances, do not essentially differ. Pliny affords some valuable statistical information, if accurate, regarding the period at which he lived, obtained from an official, and, apparently, authentic source,—the census directed by the emperor Vespasian, in the year 76 of the Christian era. From this we learn that, at the time of the computation, there were, in the part of Italy comprised between the Appennines and the Po, 124 individuals aged 100 years and upwards, viz. 54 of 100 years, 57 of 110, 2 of 125, 4 of 130, 4 of 135 to 137, and 3 of 140. At Parma, a man was living aged 120, and 2 aged 130; at Faenza, a female aged 132; and at a small town near Placentia, called Velleiacium, lived 6 persons aged 110 years each, and 4 of 120. These estimates, however, do not accord with those of Ulpian, who seems to have taken especial care to become acquainted with the facts of the case. His researches prove that the expectation of life in Rome, at that time, was much less than it now is in London, or in any of our cities. Hufeland, indeed, in his *Macrobiotics*, asserts that the tables of Ulpian agree perfectly with those afforded by the great cities of Europe, and that they exhibit the probabilities of life in ancient Rome to have been the same as those of modern London. But Doctor Hawkins, in his Elements of Medical Statistics (London, 1829), says that the tables kept by the censors for 1000 years, and constituting registers of population, sex, age, disease, &c., according to Ulpian (who was a lawyer, and a minister of Alexander Severus), refer only to free citizens, and that, to draw a just comparison between Rome and London, it would be necessary to take, among the inhabitants of the latter city, only those who were similarly circumstanced, viz. those whose condition is easy; in which case, the balance would be greatly in favour of modern times. Mr. Finlayson has ascertained, from very extensive observation on the decrement of life prevailing among the nominees of the Tontines, and other life annuities, granted by the authority of parliament, during the last forty years, that the expectation of life is above fifty years for persons thus situated, which affords the easy classes of England a superiority of twenty years above even the easy classes among the Romans.

The mean term of life among the easy classes of Paris is, at present, forty-two years, which gives them an advantage of twelve years above the Romans. In the third century of the Christian era, the expectation of life in Rome was as follows:—From birth to twenty, there was a probability of thirty years; from twenty to twenty-five, of twenty-eight years; from twenty-five to thirty, twenty-five years; from thirty to thirty-five, twenty-two years; from thirty-five to forty, twenty years; from forty to forty-five, eighteen years; from forty-five to fifty, thirteen years; from fifty to fifty-five, nine years; from fifty-five to sixty, seven years; from sixty to sixty-five, five years. Further than this the computation did not extend. The census taken from time to time in this country affords us information of an unquestionable character. The first actual enumeration of the inhabitants was made in 1801, and gave an annual mortality of one in 44.8. The third census was made in 1821, and showed a mortality of one to fifty-eight. The mortality then had decreased considerably within twenty years; which may also be said with regard to the last census in 1831. In France, the annual deaths were, in 1791, one in twenty-nine; in 1802, one in thirty; in 1823, one in forty. In the Pays de Vaud, the mortality is one to forty-nine; in Sweden and Holland, one to forty-eight; in Russia, one to forty-one; in Austria, one to thirty-eight. Wherever records have been kept, we find that mortality has decreased with civilization. Perhaps a few more persons reach extreme old age among nations in a state of little cultivation; but it is certain that more children die, and the chance of life, in general, is much less. In Geneva, records of mortality have been kept since 1590, which show that a child born there has, at present, five times greater expectation of life than one born three centuries ago. A like improvement has taken place in the salubrity of large towns. The annual mortality of London, in 1700, was one in twenty-five; in 1751, one in twenty-one; in 1801, and the four years preceding, one in thirty-five; in 1811, one in thirty-eight; and in 1821, one in forty; the value of life having thus doubled, in London, within eighty years. In Paris, about the middle of the last century, the mortality was one in twenty-five; at present, it is about one in thirty-two; and it has been calculated that, in the fourteenth century, it was one in sixteen or seventeen. The annual mortality in Berlin has decreased during the last fifty or sixty years from one in twenty-eight to one in thirty-four. The mortality in Manchester was, about the middle of the last century, one in twenty-five; in 1770, one in twenty-eight; forty years afterwards, in 1811, the annual deaths were diminished to one in forty-four; and in 1821 they seem to have been still fewer. In the middle of the last century, the mortality in Vienna was one in twenty; it has not, however, improved in the same

proportion as some of the other European cities. According to recent calculation, it is, even now, one in twenty-two and a half, or about twice the proportion of Philadelphia, Manchester, or Glasgow. Many years ago, Mr. Finlayson drew up the following table, to exhibit the difference in the value of life, at two periods of the seventeenth and eighteenth centuries.

Ages.	Mean Duration of Life, reckoning from 1693.	1789.	So that the Increase of Vitality is in the inverse ratio of 100 to
Years.	Years.	Years.	
5	41.05	51.20	125
10	38 93	48.28	124
20	31.91	41.33	130
30	27.57	36.09	131
40	22.67	29.70	131
50	17.31	22.57	130
60	12.29	15.52	126
70	7.44	10.39	140

The following is the annual mortality of some of the chief cities of Europe and America:—

Philadelphia	1 in 45.68
Glasgow	1 in 44
Manchester	1 in 44
Geneva	1 in 43
Boston	1 in 41.26
London	1 in 40
New York	1 in 37.83
St. Petersburg	1 in 37
Charleston	1 in 36.50
Baltimore	1 in 35.44
Leghorn	1 in 35
Berlin	1 in 34
Paris, Lyons, Barcelona, and Strasburg	1 in 32
Nice and Palermo	1 in 31
Madrid	1 in 29
Naples	1 in 28
Brussels	1 in 26
Rome	1 in 25
Amsterdam	1 in 24
Vienna	1 in 22½

The following is a general bill of all the christenings and burials within the City of London and Bills of Mortality, from December 15, 1830, to December 13, 1831:—

Christened—Males, 14,217; females, 14,046; total, 28,263; showing an increase of 1520 births over those of the previous year.

Buried—Males, 12,769; females, 12,568; total, 25,337.

Whereof have died,

Under two years of age	7812
Between two and five	2647
Five and ten	1031
Ten and twenty	934
Twenty and thirty	1649
Thirty and forty	1968
Forty and fifty	2175
Fifty and sixty	2169
Sixty and seventy	2237
Seventy and eighty	1786
Eighty and ninety	825
Ninety and one hundred	101
One hundred	1
One hundred and one	1
One hundred and five	1

On the average of eight years, from 1807 to 1814 inclusive, there died annually within the city of Philadelphia and the Liberties, the following proportion of persons, of different ages, compared with the total number of deaths:—

	Per Cent.
Under one year	25.07
From one to two years	10.71
Two to five	5.67
Five to ten	3.00
Ten to twenty	3.60
Twenty to thirty	8.63
Thirty to forty	10.99
Forty to fifty	7.98
Fifty to sixty	5.95
Sixty to seventy	4.29
Seventy to eighty	3.27
Eighty to ninety	1.89
Ninety to one hundred	0,50
One hundred to one hundred ten	0.0009

Another question of interest is the enquiry in what degree the various trades and professions are favourable to human life, or the contrary. Several statements have lately been published respecting this subject, but further and more copious observations are required, to afford satisfactory results. The *Literary Gazette* gives, in a tabular form, the results of a work on this subject, from the pen of Mr. Thackrah, an eminent surgeon of Leeds.

Out-of-door occupations.—Butchers are subject to few ailments, and these the result of plethora. Though more free from diseases than other trades, they, however, do not enjoy greater longevity: on the contrary, Mr. Thackrah thinks their lives shorter than those of other men who spend much time in the open air. Cattle and horse-dealers are generally healthy, except when their habits are intemperate. Fishmongers, though much exposed to the weather, are hardy, temperate, healthy, and long-lived; cart-drivers, if sufficiently fed and temperate, the same. Labourers in husbandry, &c., suffer from a deficiency of nourishment. Brickmakers, with full muscular exercise in the open air, though exposed to vicissitudes of cold and wet, avoid rheumatism and inflammatory diseases, and attain good old age. Paviers are subject to complaints in the loins, increasing with age, but they live long. Chaise-drivers, postilions, coachmen, guards, &c., from the position of the two former on the saddle, irregular living, &c., and from the want of muscular exercise in the two latter, are subject to gastric disorders, and finally to apoplexy and palsy, which shorten their lives. Carpenters, coopers, wheelwrights, &c., are healthy and long-lived. Smiths are often intemperate, and die comparatively young. Rope-makers and gardeners suffer from their stooping postures.

In-door occupations. — Tailors, notwithstanding their confined atmosphere and bad posture, are not liable to acute diseases, but give way to stomach complaints and consumption. The prejudicial influence of their employment is rather insidious than urgent: it undermines rather than destroys life. Stay-makers have their health impaired, but live to a good age. Milliners, dress-makers, and straw-bonnet-makers are unhealthy and short-lived. Spinners, cloth-dressers, weavers, &c., are more or less healthy, according as they have more or less exercise and air. Those exposed to inhale imperceptible particles of dressings, &c., such as frizers, suffer from disease, and are soonest cut off. Shoemakers are placed in a bad posture. Digestion and circula-

tion are so much impaired that the countenance marks a shoemaker almost as well as a tailor. The secretion of bile is generally unhealthy, and bowel complaints are frequent. In the few shoemakers who live to old age, there is often a remarkable hollow at the base of the breast-bone, occasioned by the pressure of the last. Curriers and leather-dressers are very healthy, and live to old age. Saddlers lean much forward, and suffer, accordingly, from headache and indigestion. Printers (our worthy co-operators) are kept in a confined atmosphere, and generally want exercise. The constant application of the eyes to minute objects gradually enfeebles these organs. The standing posture, long maintained here, as well as in other occupations, tends to injure the digestive organs. Pressmen, however, have good and varied labour. Bookbinders,—a healthy employment. Carvers and gilders look pale and weakly, but their lives are not abbreviated in a marked degree. Clock-makers are generally healthy and long-lived; watch-makers the reverse. House servants, in large smoky towns, are unhealthy. Colliers and well-sinkers—a class by themselves—seldom reach the age of fifty.

Employments producing dust, odour, or gaseous exhalations.—These are not injurious, if they arise from animal substances, or from the vapour of wine or spirits. Tobacco manufacturers do not appear to suffer from the floating poison in their atmosphere. Snuff making is more pernicious. Men in oil-mills are generally healthy. Brush-makers live to a great age. Grooms and ostlers inspire ammoniacal gas, and are robust, healthy, and long-lived. Glue and size boilers, exposed to the most noxious stench, are fresh-looking and robust. Tallow-chandlers, also exposed to offensive animal odour, attain considerable age. Tanners are remarkably strong, and exempt from consumption. Corn-millers, breathing an atmosphere loaded with flour, are pale and sickly, and very rarely attain old age. Malsters do not live long, and must leave the trade in middle life. Tea-men suffer from the dust, especially of green teas; but this injury is not permanent. Coffee-roasters become asthmatic, and subject to headache and indigestion. Paper-makers, when aged, cannot endure the effect of the dust from cutting the rags. The author suggests the use of machinery in this process. In the wet and wear and tear of the mills, they are not seriously affected, but live long.

Masons are short-lived, dying generally before forty. They inhale particles of sand and dust, lift heavy weights, and are too often intemperate. Miners die prematurely. Machine-makers seem to suffer only from the dust they inhale, and the consequent bronchial irritation. The (iron) filers are almost all unhealthy men, and remarkably short-lived. Founders (in brass) suffer from the inhalation of the volatilized metal. In the founding of yellow brass, in particular, the evolution of oxide of zinc is very great. They seldom reach forty years. Copper-smiths are considerably affected by the fine scales which rise from the imperfectly volatilized metal, and by the fumes of the spelter, or solder of brass. The men are generally unhealthy, suffering from disorders similar to those of the brass-founders. Tin-plate workers are subjected to fumes from muriate of ammonia, and sulphureous exhalations from the coke which they burn. These exhalations, however, appear to be annoying rather than injurious, as the men are tolerably healthy, and live to a considerable age. Tinners, also, are subject only to temporary inconvenience from the fumes of the soldering. Plumbers are exposed to the volatilized oxide of lead, which rises during the process of casting. They are sickly in appearance, and short-lived. House-painters are unhealthy, and do not generally attain full age.

Chemists and druggists, in laboratories, are sickly and consumptive. Potters, affected through the pores of the skin, become paralytic, and are remarkably subject to constipation. Hatters, grocers, bakers, and chimney-sweepers (a mixed association) also suffer through the skin; but, although the irritation occasions diseases, they are not, except in the last class, fatal. Dyers are healthy and long-lived. Brewers are, as a body, far from healthy. Under a robust and often florid appearance, they conceal chronic diseases of the abdomen, particularly a congested state of the venous system. When these men are accidentally hurt or wounded, they are more liable than other individuals to severe and dangerous effects. Cooks and confectioners are subjected to considerable heat. Our common cooks are more unhealthy than house-maids. Their digestive organs are frequently disordered: they are subject to headache, and their tempers rendered irritable. Glass-workers are healthy. Glass-blowers often die suddenly.

Literary occupations do not appear to be more injurious to long life than many others. Many of the first literati, most distinguished for application throughout life, have attained old age, both in modern and ancient times.

We will add a few instances of extraordinary longevity. Our own countryman, Parr, who was born in 1483, married when at the age of 120, retained his vigour till 140, and died at the age of 152. from plethora. Harvey, the distinguished discoverer of the circulation of the blood, who dissected him, found no decay of any organ. (*Philosophical Transactions*, vol. iii. 1698.) Henry Jenkins, who died in Yorkshire, in 1670, is, perhaps, the greatest authentic instance of longevity. He lived 169 years. Margaret Forster, a native of Cumberland, died in 1771, aged 136; and James Lawrence, a Scotchman, lived 140 years. A Dane, named Drakenberg, died in 1772, in his 147th year; and John Effingham, or Essingham, died in Cornwall, in 1757, aged 144. In 1792, a soldier, named Mittelstedt, died in Prussia, at the age of 112. Joseph Surrington, a Norwegian, died at Bergen, in 1797, aged 160 years. The St. Petersburg papers announced, in 1830, the death of a man 150 years old, at Moscow; and, in 1831, the death of a man in Russia, 165 years old, was reported. On May 7, 1830, died a man named John Ripkey, at the age of 108, in London. His sight remained good till the last. In 1830, a poor man, near lake Thrasimene, died 123 years old. He preserved his faculties to the last. In 1825, pope Leo XII. gave him a pension.

Belsham's Chronology informs us that twenty-one persons, who had attained the age of 130 and upwards, died between the years 1760 and 1829; of these, one was aged 166. In the same period, thirty-nine had attained the age of 120, and not 130. The number who attained the age of 110, and not 120, was thirty-six in the same space. And those who died after the age of 100, and before 110, were fifty-four within the period. Of the whole number recorded, ninety-four were natives of England, twenty-

three of Ireland, and twelve of Russia. Doubtless many more have died after the age of 100, without having had their names recorded. The northern climates afford more instances of longevity than the southern; and, although far the greater part of those who have attained extreme old age have been distinguished for sobriety, yet some of them do not appear to have been in the habit of restraining their appetites. In China, where old age is much respected, people receive presents from government when they have attained a great age.

LONGIMETRY; the measuring of lengths or distances, both accessible and inaccessible. Accessible distances are measured by the application of some measure a certain number of times, as a foot, chain, &c.; and inaccessible distances are measured by taking angles, &c., by means of proper instruments, as the *circumferentor, quadrant, theodolite,* &c. This embraces a great number of cases, according to the situation of the object and observer.

LONGITUDE, GEOGRAPHICAL; the distance measured, according to degrees, minutes, seconds, &c., on the equator, or a parallel circle, from one meridian to another, which is called the first or prime meridian. Longitude is divided into eastern and western. It is altogether indifferent through what point we draw the first meridian, but it must be settled what point we adopt. In this country Greenwich is always adopted; in Germany, the Island of Ferro; in France, the observatory at Paris; in Prussia, that of Berlin; in the United States of America, the meridian of Washington is sometimes taken as a first meridian; but Greenwich is usually adopted. Some geographers reckon from the first meridian 180 degrees west, and the same number east; others, on the contrary, reckon the longitude from the west to the east, the whole length of the equator, to 360 degrees. The longitude of any place, together with the latitude, is requisite for the determination of the true situation of the place upon the earth. From the form of our earth, it follows that the degrees of longitude must always decrease towards the poles. The degrees of latitude, on the contrary, are all taken as equal to each other, and each amounts to sixty geographical miles. The measure of a degree of longitude upon any parallel of latitude is found by multiplying the length of a degree on the equator by the co-sine (taking radius equal to 1) of the latitude of the parallel. The longitude shows the difference of time between any place and the first meridian. The sun performing its apparent revolution in twenty-four hours, a place which lies fifteen degrees further to the west than another will have noon one hour later. Places whose difference of longitude amounts to 180° have opposite seasons of the day, since in the one place it is mid-day, and in the other, at the distance of 180°, it is midnight at the same moment. The difference in longitude of any two places may also be determined by observations of the time of certain celestial phenomena, taken at both places, such as eclipses of the moon, occultations of fixed stars, and, in particular, the eclipses of Jupiter's satellites; and, *vice versâ,* we can, from the difference of longitude of two places, accurately ascertain the difference of their time. 15° upon the parallel circle correspond to one hour, 1° gives 4′ of time, 15′ give 1′ of time, 15″ give 1″ of time, &c. The difference of longitude between Boston in America and London may serve as an example. This difference is 70°, 4′, 9″; consequently, noon at London is four hours, forty-four minutes, and six seconds earlier than at Boston.

The determination of longitude at sea, or of the situation of a ship at any moment, is highly difficult and important. Parliament, in 1714, offered a reward of 20,000*l.* for an accurate method of finding the longitude at sea, within one half of a degree; but this act was repealed July 15, 1828. A watch which would preserve a uniform motion was the most suitable means that could be afforded to the navigator, who might, from the difference of the time of noon on board the ship and the time by the watch immediately determine the difference between the longitude of the place for which the watch was regulated and that wherein the ship then was. Harrison was the first who invented a chronometer of the requisite accuracy. Upon the first voyage, it deviated only two minutes in four months. Other artists followed, namely, Kendall, Mudge, Berthoud, Le Roy, &c.; and Arnold, Vulliamy, and Dent have prepared such accurate chronometers that they have been used for the determination of longitude upon land, as well as at sea, with great success. Nevertheless, astronomical observations furnish the most exact methods of determining longitude. As eclipses and occultations are comparatively rare, and are somewhat difficult of observation, the distances of the moon from the sun or some of the fixed stars have been adopted for the calculation of longitude, because these can be measured almost every night, and an accurate knowledge of the moon's orbit is the only thing requisite thereto.

Longitude in the heavens, as that of a star, &c., is an arc of the ecliptic comprehended between the first of Aries and a circle perpendicular to the ecliptic, passing through the place of the star. The computation is made according to the signs of the ecliptic. The longitude of a star is found by means of its right ascension and declination. It changes on account of the precession of the equinoxes. (See PRECESSION.)

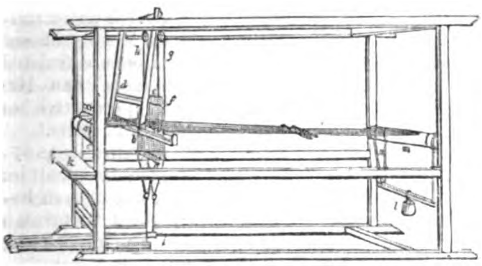
LOOM. This simple machine appears to have been originally invented in the East, and traces of it in its primitive simple form may still be found in the interior of India. The anonymous author of a treatise on the manufacture of silk, when speaking of the common forms of the loom, says, that, simple as they are, they can yet be favourably contrasted with the rude contrivances still pursued in India, where the wretched weaver performs his labours in the open air, choosing his station under trees whose shade may protect him from the scorching rays of the sun. Here, extending the threads which compose the warp of his intended cloth lengthwise, between two bamboo rollers, which are fastened to the turf by wooden pins, he digs a hole in the earth large enough to contain his legs when in a sitting posture; then, suspending to a branch of a tree the cords which are intended to cause the reciprocal raising and depressing of the alternate threads of his warp, he fixes underneath and connected with the cords two loops, into which inserting the great toe of either foot, he is ready to commence his operations. The shuttle with which he causes the cross threads or *woof* to interlace the *warp* is in form like the netting needle; and, being somewhat longer than the breadth of the warp, is made to perform the office of a batton, by striking the threads of the woof close up to each other.

With this rude apparatus the patient Indian suc-

ceeds in weaving fabrics which for delicacy of texture cannot be surpassed, and can hardly be rivalled, by the European weaver, even when his labours are aided by the most elaborate machinery. But it is only in climates where the absolute natural wants of men are few, and under systems of government where the oppressions of the dominant caste deprive the unhappy bulk of the people of all means for attaining more than suffices for the barest supply of those wants, that such labours can be so performed.

The art of weaving varies but little, whatever may be the material which is the subject of the manufacture. The principal difference discernible in the construction of looms intended for the weaving of silken or of woollen fabrics consists in the greater strength and stability required for the latter machine, in consequence of the less delicate nature of the substance employed.

The simple loom ordinarily used in weaving plain silks is represented in the accompanying engraving,



and may be thus described: *m* is the beam, or yard-roll, on which the threads which form the warp are wound. Having procured a sufficient quantity of single threads to form the warp, it is then passed through a sort of comb, *b*, and attached to the loom. *a* is the cloth-beam, or breast-roll, to which the ends of the warp are also attached, and on which the woven silk is wound when finished; *l* is a weight attached to the frame of the loom, and suspended over the yard-roll, to produce, by the friction of its cord, the requisite tension of the threads of the warp; *i* are the treadles, on which the weaver presses his feet alternately; and as the one treadle is attached to one portion of the heddle or harness, *h*, whilst the other treadle is attached to the heddle *e f g*, it will be evident that the depression of each treadle will correspondingly influence the position of its heddle. The two heddles are each formed of two horizontal sticks, connected through the whole extent by numerous small cords of an equal length; and the two heddles are so united by a rope and pulley, as shown in the engraving, that the depression of the one must cause the raising of the other. These heddles, which are commonly called the harness of the loom, are furnished with loops at the points where they will be intersected by the warp, each individual thread of which is passed, in regular succession, through the cords of one or other of the heddles, so that each alternate thread of the warp is passed through the loops of the one heddle, while the intermediate threads are passed through the cords of that one, and through the loops of the other heddle. It is now evident that the depression of one heddle by means of the treadle will cause the depression of all the threads of the warp which pass through its loops, and at the same time will raise the other heddle, together with all the intermediate threads of the warp which pass through its loops, leaving between the two divisions of threads a space of about two inches, for the passage of the shuttle. A modern improvement substitutes for the loops small metallic eyes, through which the warp threads are passed, and by this means the wearing of the threads is in some measure avoided. *d* is the reed, which is composed sometimes of small portions of split reeds, or canes, but most frequently of flattened wires. These are fixed, like the teeth of a comb, in a frame, which rests upon the shuttle-race, and the threads of the warp are passed through the interstícial spaces of the reed. These are covered by a top-piece, having a longitudinal groove along its lower side, and which is called the lay-cap. *k* is the weaver's seat, and being hung by rounded ends, resting in corresponding brackets fixed to the framing, the position of this seat accommodates itself to the convenience of the weaver in the different movements of his labour. It must be lifted up when the weaver either takes or quits his seat at the loom, and can be readily replaced.

Having thus given our readers an account of the loom for plain weaving, we must briefly notice the fanciful and ornamental part of the business. Figures, or patterns, are produced in the loom by employing threads of different colours either in the warp or weft. By the proper use of these, some colours may be concealed, or kept back, whilst others are thrown into the front of the fabric. These are made to change places at the will of the weaver, or, as in the case of the *Jaccard* loom, by the agency of machinery. In other cases, the same end is accomplished by employing two or three shuttles, with different coloured threads, either of which may be introduced at pleasure. (See POWER LOOM.)

LOTH; a German weight, the half of an ounce, or the thirty-second part of a pound avoirdupois. The lead used by navigators and mechanics is also called *Loth* in German.

LOTION, in *medicine* and *pharmacy*, is a wash for beautifying the skin, by clearing it of the deformities occasioned by a preternatural secretion. Almost all the lotions advertised for sale contain much deleterious matter, and therefore ought never to be had recourse to.

LOTTERY; a scheme for the distribution of prizes by chance. Lotteries, like every other species of gambling, no doubt have a pernicious influence upon the character of those concerned in them. Though this influence is not so direct, and the immediate consequences are not so disastrous, as those of some other species of gambling, which call into exercise the violent passions, and stake the gambler's whole fortune upon a single chance or exertion of skill,—still, as this kind can be carried on secretly, and the temptations are thrown in the way of both sexes, all ages, and all descriptions of persons, it spreads more widely in a community, and may thus silently affect the sober, economical, and industrious habits of a people more extensively and deeply than those species of gambling which are attended with greater turbulence, and a train of other vices. Lotteries are of different kinds: I. *Numerical lottery;* invented by the Genoese. At the elections of the counsellors, the names of the candidates were cast into a vase, and then into a "wheel of fortune," when wagers were laid upon the event of the elections: the state finally

undertook the superintendence of the bank. It is said that Benedetto Gentile, a counsellor, first introduced this lotto in 1620; and because the name *Gentile*, by chance, had never been drawn, the popular belief prevailed that the devil had carried him off, together with his name, to punish him for this unlucky invention. Numbers were afterwards substituted instead of the names of eligible noblemen, and hence the lotto assumed its present form. The numbers from one to ninety are used; from these, on the day of drawing, five numbers are always drawn. Out of the ninety numbers, each adventurer chooses for himself such and as many numbers as he likes, and specifies with what sum and upon what kind of chance he will back each selected number; whereupon he receives a printed ticket. In this lottery there are four kinds of chances: 1. An *estrado*, so called, which requires only one number among the five that are drawn, and in which the successful adventurers receive fourteen times the stake. By this the lotto gains sixteen per cent., because there are seventeen blanks to one prize. 2. The *wager*, in which a man lays a wager, as it were, with the lotto, that one of the selected numbers will have the first, second, third, fourth, or fifth place in the order of drawing. Should this event happen in the drawing, the bettor obtains sixty-seven times the sum deposited. By this the lotto gains about twenty-five per cent. 3. The third is an *ambo*, in which, if, of the numbers drawn, there are two which the adventurer has pitched upon, he receives from the lotto 240 times the stake. In this case the lotto gains thirty-seven per cent., there being 399 blanks to one prize. 4. The last is a *terno*, by which the lotto gains fifty-four per cent., there being 11,347 blanks to one prize. It requires the adventurer to pitch upon three of the five numbers drawn, in which case he wins 4800 times the amount of the stake. The *quaternes* and *quinternes* are a later invention, and seldom applied to practice, because the lotto thereby gains eighty-eight per cent. and more. The lotto was every where patronized by the multitude, with an interest increasing almost to madness. Wise governments soon saw into the destructive tendency of the lotto, and put an end to it, or prohibited adventuring in it under a severe penalty.

Though the profit of the lotto banks was evident, yet fortune, by means of *ternes* and *quinternes*, brought many of them to ruin, or at least to its very verge, and hence, if numbers were backed too frequently, the conductors took the precaution to secure themselves, by declaring before the drawing that such numbers were full, and they could receive no further stake upon them. Frauds also were practised by means of violent riding and carrier-pigeons, on those lottos the under offices of which, being placed at a distance, were accustomed to sell tickets after the drawing in the principal offices had commenced. II. *The proper lottery*, called also *class lottery*, when divided into classes. Its origin is more ancient than that of the lotto. It has been referred to the Roman *Congiaria*. It is more probable that it originated from the transfer of merchandise by lot, of which method the Italian merchants made use even in the middle ages, and of which we also find traces in Germany; for, as early as 1521, the council at Osnaburg is said to have established lotteries for merchandise. So also in France, under Francis I., similar lotteries for merchandise were permitted to the merchants, under the inspection of government, in consideration of certain duties.

A money lottery was established at Florence in 1530. In 1571 there appears to have been a public officer in Venice for the inspection of the lottery. From Italy, lotteries passed into France, under the name of *blanque* (from the Italian *bianca*, because most of the tickets were blanks, mere white paper, *carta bianca*). In 1582 and 1588 Louis de Gonzaga established such a *blanque* in Paris, for providing poor girls of his estates with dowries; and, in 1656, Lawrence Tonti (from whom the Tontines derive their name) sought to establish a large *blanque royale*, which was first accomplished in 1660. Since this time, there have been in France only *lotteries royales*, the income of which is commonly applied to public buildings. This iniquitous traffic has been revived in France, on a much larger and more destructive scale than it has attained in any other country. In 1810 lotteries were drawn twice a week at Paris, and so often at Bordeaux, Brussels, Lyons, and Strasburg, as to afford one every other day. Twelve millions of francs were yearly produced to government by this public gambling; and it has been estimated that, at Paris, the result has been more than 100 suicides annually. It is, however, productive of much less harm than the private tables in Paris.

In this country, the first lottery occurs in 1567-1568. In 1612 a lottery was granted in behalf of the Virginia Company, and, in 1680, one also in behalf of the undertaker of an aqueduct to furnish London with water. In 1709 the rage for private, and, in many instances, most fraudulent lotteries, was at its height in England, and shop-keepers of all descriptions disposed of their goods in this way, the price of tickets being as low as half-a-crown, a shilling, or even sixpence. Towards the close of the year, an existing act of parliament was put in force for their suppression, and another to the same purpose was passed in the 10th of queen Anne. The first parliamentary lottery was instituted in 1709, and, from that time till 1824, no session passed without a lottery bill. In 1826 lotteries were formally abolished in this country, but in the present parliament (1833) this species of legalized gambling was revived, under the pretext that it furnished the only practicable mode of effecting some important improvements in the city of Glasgow. As early as 1549 a lottery was drawn in Amsterdam, to procure money for the erection of the tower of a church, and, in 1595, one at Delft. In 1653 one was established at Hamburg, according to the Dutch method; in 1699 the first class lottery appeared at Nuremberg; and, in 1740, the first one was drawn in Berlin. Most of the late German lotteries are drawn in classes in order to facilitate the sale of tickets. The great lottery of Hamburg goes upon the plan of one drawing. Latterly, lotteries for merchandise of all kinds, under the inspection of government, have been frequent in Germany. The managers of the principal lotteries sell only whole tickets. Brokers, however, divide them into halves, quarters, eighths, and even sixteenths, in order to facilitate their sale. In some places they even let out tickets, and parts of tickets, upon a particular number of drawings; in which case they are not obliged to pay the prize which may fall to the ticket, unless it be drawn within the stipulated number of drawings. If the principal prizes remain for a long time in the lottery, so that the

probability of being able to obtain them increases at each successive drawing, then a great profit is made in buying and selling tickets, and there are cases in which, in the last drawings, ten and even twenty times the original price of the ticket have been demanded. Lately, in the Austrian monarchy, in the kingdom of Bavaria, and in the duchy of Mecklenburg, estate lotteries have been got up, and manufactories, the estates of noblemen, and even whole lordships, have been disposed of by lottery, under public sanction, and ordinarily under the security of important mercantile houses, which undertook the disposal of the property, in order to settle the debts of the owners. A money lottery has ordinarily been combined with them.

When the credit of the state is low, or when the rate of interest is high, efforts have been made to induce capitalists to put their money into the hands of the state, by means of a lottery, which gives them the expectation of a premium above the customary interest of the country. For example: If a government is uncertain of obtaining, or cannot obtain, money at seven per cent., it may, perhaps, effect its object by offering four per cent. for a loan, and dividing the remaining three per cent. among the lenders by means of a lottery; for the hope of winning the great prizes in the lottery, in addition to the certainty of disposing of their capital at four per cent., has a stronger influence on many men than the offer of seven per cent interest. In this way loans have been raised in Austria, Denmark Baden, Prussia, and other states. By this means, in Prussia, stocks to the amount of 30,000,000*l.* were sold at their full nominal value, while, in the market, they were current only at about seventy per cent. In most if not all of the United States of America, lotteries not specially authorised by the legislatures of the states are prohibited, and the persons concerned in establishing them are subjected to a heavy penalty. In some of the states, lotteries have been very numerous. This is the case with several of the southern states, Virginia, Maryland, and particularly Tennessee. They have also been numerous in New York. The object for which they have been granted has been generally the assistance of literary or benevolent institutions, colleges, academies, hospitals, asylums, or of public works, as roads, bridges, the improvement of the navigation of rivers, &c. Their pernicious effects have induced the legislatures of some of the United States to decline granting them in any case.

LUNAR YEAR. This division of time consists of twelve moons, or 354 days. But it is so ill adapted for the computation of time in a civilized nation that none but Mahometans continue to use it. Amongst those nations which still employ it, many persons can scarcely remember their fasts and festivals as they alternately wander from summer to winter, and again from winter to summer; and their seed-time and harvest change in the same way from the beginning of the year to the end.

The *luni-solar* year is that in which the months are regulated according to the course of the moon, but to which from time to time a month is added whenever the year would range too widely from its original situation. This year is inconvenient, from its varying duration; but as, in a long course of years, the months remain nearly in the same situation, it is less objectionable than the pure lunar year. It was the mode of computation originally adopted by the Greeks and Romans, and is even now that of the Tartars and Japanese.

LUNACY, in *medicine*. See MENTAL DERANGEMENT.

LUNETTE, in *fortification*; a very vague expression, which, in its original signification, probably comprised every detached work built in the form of an angle, and consisting of but two faces. It was afterwards used in a more limited sense, to denote, 1. Small, generally irregular, works, with or without flanks, that are placed in the principal ditch, before the ravelins or other out-works, for the purpose of covering such places of the chief rampart as may be seen from the open field, or of defending from the side such points as, through a mistake in the original plan of the fortifications, were left unprotected, the guns from the bastions not being able to reach them. 2. Advanced works on or before the glacis are sometimes constructed in the form of an angle, sometimes in the form of a bastion. Lunettes, skilfully disposed on the weak fronts of a place, and arranged in one or two lines, so as to flank one another, may check the approach of the enemy for a considerable time, by obliging him to make his trenches at a greater distance than he would otherwise have done, and subjecting him to losses in the capture of each lunette. Particular attention must be paid to dispose them in such a manner as to render it impossible for the enemy to attack two lunettes at the same time. (See FORTIFICATION.)

LUNGS; the organs of respiration in the mammalia (man, quadrupeds, and the cetaceous animals), birds, and reptiles. The lungs are situated in the chest, and are divided into two parts, called *lobes*. They are enveloped in a delicate and transparent membrane, derived from the pleura, through which they have the appearance of net-work, and are connected with the spine by the pleura, with the neck by the windpipe, and with the heart by the roots of the pulmonary artery and veins. In their specific gravity, they are the lightest of all the animal organs, even when exhausted of air; hence their name of *lights*. To the touch, they are soft, spongy, and elastic. In their internal structure, they are composed of an infinite number of membranous cellular blood-vessels, nerves, and lymphatics, all connected by other cellular substances. The cells communicate with each other, but have no communication with the cellular substance: small tubes arise from them, which are finally united into one large tube from each lobe: and these two at length join to form the windpipe. The blood-vessels called the *pulmonary* vessels are destined to distribute the blood through the cells, for the purpose of subjecting it to the action of the air, while the bronchial vessels are intended to supply the blood which nourishes the lungs. The cetacea (whales, seals, &c.) breathe by lungs, and are therefore obliged to ascend, at intervals, to the surface of the water, to obtain a supply of atmospheric air. The respiratory orifice, in these animals, is not situated at the extremity of the snout, but on the top of the head. In birds, the lungs are smaller than in quadrupeds, but they have air distributed throughout their muscular system and in the cavities of the bones.

The lungs afford a means of ascertaining whether a new-born child, which is found dead, was or was not living when born,—a question often of great importance in forensic medicine. The lungs of the

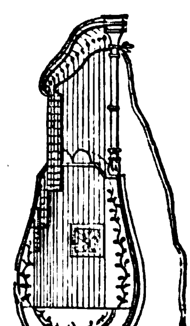
infant are placed in water to see whether they will swim or sink. Before birth, the lungs are dark red, contracted into a small place within the cavity of the breast, firm, and specifically heavier than water. They therefore sink in water, whether they are entire or cut into pieces; and, when cut, no air-bubbles come forth, either in or out of the water, nor does much blood appear. But if the infant has lived after birth, and therefore breathed, air has entered the lungs, has thus enlarged the cavity of the chest, and the lungs themselves are expanded, appear ot a loose, spongy texture, of a pale red colour, cover the heart, and fill the chest. They then swim in water, as well in connection with the heart as without it, as well entire as in pieces. If cut, a peculiar sound is audible; air proceeds from them, and rises, if they are pressed under water, in small bubbles. From the incisions in the lungs, red blood issues.

Against this test it has been objected—1. That air may be found in the lungs, though the infant never breathed. This could happen, however, only (1) from air having been blown into them; but, in this case, the chest of the infant is not arched, very little blood is to be found in the lungs, and it is not bright red: (2) from putrefaction; but, in this case, the other parts of the body would also be affected by putrefaction: the lungs are not expanded, pale-red air-bubbles show themselves only on the surface, and not in the interior substance, unless the highest degree of putrefaction has taken place. 2. It is said that the child may have breathed, and therefore lived, without air being found in the lungs. This is not proved, and is at variance with the received ideas of the manifestation of life. 3. One part of the lungs may swim, another may sink. This can happen only with lungs in a diseased state, and would only prove an attempt of the infant to breathe, without the possibility of living. 4. That a child may have lived without breathing; but this state of apparent death cannot be called life: life cannot be supposed without breath. If all precautions are taken, all attending circumstances considered, the external appearance of the infant well observed, and the state of the other intestines examined, the foregoing test may be considered as sufficient for the decision of the question whether a child has lived after birth or not. Another kind of test by means of the lungs has been proposed, which is founded on the proportion of the weight of the whole body to a lung which has breathed and one which has not; and still another, which rests on the circumference of the chest before and after breathing has commenced; but both are more complicated, troublesome, and less certain than the former one.

LUPULIN. M. Planche first ascertained that the three active ingredients of the hop, viz. the oil, resin, and bitter principle, reside in the brilliant yellow grains scattered over the calicinal scales of the cones which serve as their envelope. MM. Payen and Chevalier have since confirmed this position. This matter, when insulated, is of a golden yellow colour, in little grains, without consistence, which attach themselves to the fingers, and render them rough. It has a penetrating aromatic odour: 200 parts of it afforded, 1. water; 2. essential oil; 3. carbonic acid; 4. subacetate of ammonia; 5. traces of osmazome; 6. traces of fatty matter; 7. gum; 8. malic acid; 9. malate of lime; 10. bitter matter, 25 parts; 11. a well characterized resin, 105 parts; 12. silica, 8 parts; 13. traces of carbonate, muriate, and sulphate of potash; 14. carbonate and phosphate of lime; 15. oxide of iron and traces of sulphur. The bitter matter, introduced into the stomach, destroys appetite.

LUTE is an instrument which originated from the ancient lyre. Some, however, think that it was introduced into Spain by the Moors, and from thence into Italy, where it received the name of *liuto*. The *chelys*, or *testudo*, of the Romans, was probably a similar instrument. It was formerly much in use, and contained only five rows of strings, to which one, or more, were afterwards added. The lute consists of four parts, viz. the table; the body, which has nine or ten sides; the neck, which has as many stops or divisions; and the head, or cross, in which the screws for turning it are inserted. In playing this instrument, the performer strikes the strings with the fingers of the right hand, and regulates the sounds with those of the left. The notes for the lute are generally written on six lines, and not on five. There were formerly various kinds in use. The lute, simply constructed, is called the *French lute;* if it has two necks, one of which sustains the base notes, it is called a *theorbo;* if the strings of the *theorbo* are doubled, it is called an *arch-lute*. The difficulty of playing upon this instrument, as well as that of tuning it, is probably the reason that it has gone out of use.

The difficulties inseparable to the common lute has induced a distinguished foreigner to turn his attention towards the general arrangement of its parts. Indeed, the instrument we are about to describe under this title possesses all the characteristics of the harp. Signor Ventura, the inventor of this instrument, has so combined the principles of the harp, lute, and guitar, as to enable the performer to stop the treble strings on a finger board, by which he materially increases its compass, and yet retains the fulness and sweetness of its tones. The engraving will give a perfect notion of the general arrangement of the instrument, and it may only be necessary to add that the strain on its neck is considerably less than in a harp of the same size, and, as such, that it must continue much longer in tune.



LUXATION, in *surgery*, is the removal of a bone out of its place or articulation, so as to impede or destroy its proper motion or office; hence luxations are peculiar to such bones as have movable joints.

LYCANTHROPY; defined by Cottgrave as "a frenzie or melancholie, which causeth the patient (who thinks he is turned woolf) to flee all company and hide himself in dens and corners." Herodotus, with great *naïveté* tells us, that, when he was in Scythia, he heard of a people that once a year changed themselves into wolves, and then resumed their original shape; "but," adds he, "they cannot make me believe such tales, although they not only tell them, but swear to them." But the lycanthropes of the middle ages, or *loups-garoux*, as they were called by the French, were sorcerers, who, during their wolfhood, had a most cannibal appetite for human flesh. The Germans call them *Währwölfe*. Many marvellous stories are told by the writers of the middle

ages of these wolf-men, or *loups-garoux*, and numerous narratives remain of victims committed to the flames for this imaginary crime, often on their own confessions.

Lymph; an aqueous liquid, colourless, insipid, and diaphanous, diffused through the whole animal economy, in vessels called *lymphatics*. If allowed to stand, it separates into two parts, like the blood—a serous fluid, and a solid, or clot. The lymph serves to repair losses of the blood, by bringing to it various materials from different parts of the system, and chyle, which is mixed with the lymph in the thoracic duct. It seems also to remove those elements of nutrition whose place is to be supplied by others, and to transmit them to the surface. The uses and history of lymph, however, are yet but imperfectly known. The lymphatic vessels were not known till towards the middle of the seventeenth century. They are small, thin, transparent, furnished with valves, like the veins, and spread through different parts and organs. The cause of the circulation of the lymph is unknown, as there does not appear to be any impelling organ analogous to the heart. It has been supposed that the absorbent power exercised at their mouths impels the liquid forward, that already absorbed being thus displaced by the new absorptions. These vessels arise in every part of the body, and terminate in the thoracic duct.

Lyre; the most ancient stringed instrument among the Egyptians and Greeks. The mythological tradition of the origin of the Egyptian lyre, the more ancient of the two, is curious. After an inundation of the Nile, a tortoise was left ashore among other animals; after its death, its flesh decayed, and some of the tendons were dried by the sun, so as to produce a sound when touched by Hermes, as he was walking on shore. He immediately made an instrument in imitation of it, and thus invented the lyre. This lyre, originally, had but three strings. The Greeks ascribed the invention of the lyre to their Hermes (Mercury), the son of Jupiter and Maïa. They also say that Hermes first used the shell of a tortoise. According to others, Mercury merely improved the invention of the Egyptians. The muses, after this, invented a tone, and Orpheus, Linus, and Thamyras, one each. These, being added to the three-stringed Egyptian lyre, gave rise to the heptachord, or seven-stringed lyre of the Greeks. The invention of the instrument has also been ascribed to each of its chief improvers. The Egyptian and Grecian lyres were, at first, strung with the sinews of animals. The number of the strings was at last increased to eleven. It was played with the *plectrum*, or lyre-stick, of ivory or polished wood; also with the fingers. The lyre was called by different names—*lyra, phorminx, chelys, barbitos, barbiton, cithara.* The body of the lyre was hollow, to increase the sound.

Few objects are so graceful in form, and susceptible of such varied applications in the fine arts, as the lyre, which is even yet used as a musical instrument. It is the symbol of Apollo; yet other deities also bear the lyre; and mythology mentions many gods who distinguished themselves on this instrument. It was played by educated Greeks in general; and, Themistocles having once declined playing when requested, he was considered a person without cultivation. In a work of Doni, entitled *Lyra Barberina*, the various forms of the lyre are collected in two large volumes.

MACCARONI, a preparation of fine flour, which forms a favourite article of food among the Italians. It is eaten in various ways, generally simply boiled, and served up with grated cheese. Maccaroni, is generally made in pieces resembling a long pipe handle, of small diameter; sometimes, however, in other shapes, as flat, square, &c. It is a national dish of the Italians, particularly of the Neapolitans, and is a wholesome food. It is made best in the neighbourhood of Naples, whole villages living almost solely by the manufacture; and, in Naples, it is continually sold in the streets, cooked for the lower classes, particularly for the *lazzaroni*. The pieces being very long, and being held in the fingers during the process of eating, some skill is required to manage them. This fashion of eating yard-long maccaroni forms a subject of ridicule against the Neapolitans in more than one Italian comedy. The modes of cooking maccaroni are various; the simplest is the best. Maccaroni is well made at Aix in France, and pretty well in Germany.

Mace. Clubs of various descriptions are found among almost all savages, formed of a hard and heavy wood, some broad and flat, others round, angular, long, or short, some plain and rude, others neatly carved. From this simple implement, the mallet, hammer of arms, and mace originated, which were generally used, of old, both in Great Britain and on the continent of Europe. The gradual progress of improvement having rendered armour impenetrable by edged weapons, some instrument of effectual demolition became necessary. An author on military affairs, of the sixteenth century, recommends a leaden mallet, five feet long. The mallet was wielded with both hands, and horsemen had it hung by a thong or chain from the pommel of the saddle. The hammer of arms greatly resembled a common hammer. It differed from the mallet in being square, or a little rounded or convex, while one side of the mallet was square and the other pointed or edged.

The mace in its simplest form is only an iron club, short, and strong. Its shape varied among different nations and at different times. One, still preserved, is of iron, two feet one inch long, with a hollow handle, and a head seven inches long, consisting of seven iron leaves perpendicularly fixed round a cylinder, and equidistant. The whole weighs three pounds nine ounces. Two maces, said to have belonged to Roland and Oliver de Roncevaux, famous champions under Charlemagne, were preserved in France towards the beginning of the last century, and perhaps later, consisting of a handle two feet long, to which an iron ball was attached by a triple chain. It appears that the ball was frequently covered with iron spikes, and was attached to the handle by a single chain. Mr. Grose states that similar implements were long used by the trained bands of London, under the names of *morning stars*.

Mace; the outer, fleshy, and coriaceous cover of the nutmeg. When the fruit is gathered, the mace is carefully separated from the nut, dried in the sun, and afterwards packed in chests of different sizes, in which state it is obtained in commerce. (See Nutmeg.)

Machinery. The utility of machinery, in its application to manufactures, consists in the addition

which it makes to human power, in the economy of human time, and in the conversion of substances apparently worthless into valuable products. The forces derived from wind, from water, and from steam, are so many additions to human power, and the total inanimate force thus obtained in Great Britain (including the commercial and manufacturing) has been calculated, by Dupin, to be equivalent to that of 20,000,000 of labourers. Experiments have shown that the force necessary to move a stone on the smoothed floor of its quarry is nearly two-thirds of its weight; on a wooden floor, three-fifths; if soaped, one-sixth; upon rollers on the quarry floor, one-thirty second; on wood, one-fortieth. At each increase of knowledge, and on the contrivance of every new tool, human labour is abridged: the man who contrived rollers quintupled his power over brute matter. The next use of machinery is the economy of time, which is too apparent to require illustration, and may result either from the increase of force or from the improvement effected in the form of tools, or from both united. Instances of the production of valuable substances from worthless materials are constantly occurring in all the arts; and, though this may appear to be merely the consequence of scientific knowledge, yet it is evident that science cannot exist, nor could its lessons be made productive by application, without machinery.

In the history of every science we find the improvements of its machinery, the invention of instruments, to constitute an important part. The chemist, the astronomer, the physician, the husbandman, the painter, the sculptor, is such only by the application of machinery. Applied science in all its forms, and the fine and useful arts, are the triumphs of mind, indeed, but gained through the instrumentality of machinery. In the infancy of any branch of manufactures we always commence with *tools*, which are ultimately converted into *machines;* but the distinction between the two is so accurately given by Mr. Babbage, in his work on the economy of machinery, that we cannot do better than quote it verbatim.

"The difference between a *tool* and a *machine* is not capable of very precise distinction; nor is it necessary, in a popular explanation of those terms, to limit very strictly their acceptation. A *tool* is usually more *simple* than a machine; it is generally used with the hand, whilst a machine is frequently moved by animal or steam power. The simpler *machines* are often merely one or more *tools* placed in a frame, and acted on by any moving power. In pointing out the advantages of *tools* we shall commence with some of the simplest.

"To arrange twenty thousand needles thrown promiscuously into a box, mixed and entangled with each other in every possible direction, in such a form that they shall be all parallel to each other, would, at first sight, appear a most tedious occupation; in fact, if each needle were to be separated individually, many hours must be consumed in the process. Yet this is an operation which must be performed many times in the manufacture of needles; and it is accomplished in a few minutes by a very simple *tool,* nothing more being requisite than a small flat tray of sheet iron, slightly concave at the bottom. The needles are placed in it and shaken in a peculiar manner, by throwing them up a very little, and giving at the same time a slight longitudinal motion to the tray. The shape of the needles assists their arrangement; for if two needles cross each other (unless, which is exceedingly improbable, they happen to be precisely balanced) they will, when they fall on the bottom of the tray, tend to place themselves side by side, and the hollow form of the tray assists this disposition. As they have no projection in any part to impede this tendency, or to entangle each other, they are, by continually shaking, arranged lengthwise, in three or four minutes. The direction of the shake is now changed, the needles are but little thrown up, but the tray is shaken endways; the result of which is that in a minute or two the needles which were previously arranged endways become heaped up in a wall, with their ends against the extremity of the tray. They are now removed by hundreds at a time, by raising them with a broad iron spatula, on which they are retained by the fore-finger of the left hand. During the progress of the needles towards their finished state, this parallel arrangement must be repeated many times; and, unless a cheap and expeditious method had been devised, the expense of manufacturing needles would have been considerably enhanced.

"Another process in the art of making needles furnishes an example of one of the simplest contrivances which can come under the denomination of a *tool.* After the needles have been arranged in the manner just described, it is necessary to separate them into two parcels, in order that their points may be all in one direction. This is usually done by women and children. The needles are placed sideways in a heap, on a table, in front of each operator, just as they are arranged by the process above described. From five to ten are rolled towards this person by the forefinger of the left hand; this separates them a very small space from each other, and each in its turn is pushed lengthwise to the right or to the left, according as its eye is on the right or the left hand. This is the usual process, and in it every needle passes individually under the finger of the operator. A small alteration expedites the process considerably; the child puts on the forefinger of its right hand a small cloth cap or finger-stall, and, rolling out of the heap from six to twelve needles, he keeps them down by the forefinger of the left hand, whilst he presses the forefinger of the right hand gently against their ends: those which have the points towards the right hand stick into the finger-stall; and the child, removing the finger of the left hand, slightly raises the needles sticking into the cloth, and then pushes them towards the left side. Those needles which had their eyes on the right hand do not stick into the finger-cover, and are pushed to the heap on the right side previously to the repetition of this process. By means of this simple contrivance each movement of the finger, from one side to the other, carries five or six needles to their proper heap; whereas, in the former method, frequently only one was moved, and rarely more than two or three were transported at one movement to their place.

"Various operations occur in the arts in which the assistance of an additional hand would be a great convenience to the workman, and in these cases tools or machines of the simplest structure come to our aid: vices of different forms, in which the material to be wrought is firmly grasped by screws, are of this kind, and are used in almost every workshop;

but a more striking example may be found in the trade of the nail-maker.

"Some kinds of nails, such as those used for defending the soles of coarse shoes, called hobnails, require a particular form of the head, which is made by the stroke of a die. The workman holds the red-hot rod of iron out of which he forms them in his left hand; with his right hand he hammers the end of it into a point, and, cutting the proper length almost off, bends it nearly at right angles. He puts this into a hole in a small stake-iron immediately under a hammer connected with a treadle, which has a die sunk in its surface corresponding to the intended form of the head; and, having given one part of the form to the head by the small hammer in his hand, he moves the treadle with his foot, which disengages the other hammer, and completes the figure of the head, the returning stroke produced by the movement of the treadle striking the finished nail out of the hole in which it was retained. Without this substitution of his foot for another hand, the workman would probably be obliged to heat the nails twice over.

"Another, although fortunately a less general substitution of tools for human hands, is used to assist the labour of those who are deprived by nature or by accident of some of their limbs. Those who have had an opportunity of examining the beautiful contrivances for the manufacture of shoes by machinery which we owe to the fertile invention of Mr. Brunel must have noticed many instances in which the workmen were enabled to execute their task with precision, although labouring under the disadvantage of the loss of an arm or a leg. A similar instance occurs at Liverpool, in the Institution for the Blind, where a machine is used by those afflicted with blindness for weaving sash-lines; it is said to have been the invention of a person suffering under that calamity. Other instances might be mentioned of contrivances for the use, the amusement, or the instruction of the wealthier classes, who labour under the same natural disadvantages. These triumphs of skill and ingenuity deserve a double portion of our admiration when applied to mitigate the severity of natural or accidental misfortune—when they supply the rich with occupation and knowledge — when they relieve the poor from the additional evils of poverty and want."

All machines are intended either to produce power, or merely to transmit power and execute work. Of the class of mechanical agents by which motion is transmitted—the lever, the pulley, the wedge—it has been demonstrated that no power is gained by their use, however combined. Whatever force is applied at one part can only be exerted at some other, diminished by friction and other incidental causes; and whatever is gained in the rapidity of execution is compensated by the necessity of exerting additional force. These two principles should be constantly borne in mind, and should teach us to limit our attempts to things which are possible. (See HYDRAULICS, HYDROSTATICS, MECHANICS, and STEAM-ENGINE.)

1. *Accumulating Power*. When the work to be done requires more force for its execution than can be generated in the time necessary for its completion, recourse must be had to some mechanical method of preserving and condensing a part of the power exerted previously to the commencement of the process. This is most frequently accomplished by a fly-wheel, which is a wheel having a heavy rim, so that the greater part of the weight is near the circumference. It requires great power, applied for some time, to set this in rapid motion, and, when moving with considerable velocity, if its force is concentrated on a point, its effects are exceedingly powerful. Another method of accumulating power consists in raising a weight and then allowing it to fall. A man, with a heavy hammer, may strike repeated blows on the head of a pile without any effect; but a heavy weight, raised by machinery to a greater height, though the blow is less frequently repeated, produces the desired effect.

2. *Regulating Power*. Uniformity and steadiness in the motion of the machinery are essential both to its success and its duration. The governor, in the steam-engine, is a contrivance for this purpose. A vane or fly of little weight, but large surface, is also used. It revolves rapidly, and soon acquires a uniform rate, which it cannot much exceed, because any addition to its velocity produces a greater addition to the resistance of the air. This kind of fly is generally used in small pieces of mechanism, and, like the heavy fly, it serves to equalize the moving power.

3. *Increase of Velocity*. Operations requiring a trifling exertion of force may become fatiguing by the rapidity of motion necessary, or a degree of rapidity may be desirable beyond the power of muscular action. Whenever the work itself is light, it becomes necessary to increase the velocity in order to economise time. Thus, twisting the fibres of wool by the fingers would be a most tedious operation. In the common spinning-wheel the velocity of the foot is moderate, but, by a simple contrivance, that of the thread is most rapid. A band, passing round a large wheel, and then round a small spindle, effects this change. This contrivance is a common one in machinery.

4. *Diminution of Velocity*. This is commonly required for the purpose of overcoming great resistances with small power. Systems of pulleys afford an example of this.

5. *Spreading the action of a force exerted for a few minutes over a large extent of time*. This is one of the most common and useful employments of machinery. The half minute which we spend daily in winding up our watches is an exertion of force which, by the aid of a few wheels, is spread over twenty-four hours. A great number of automata, moved by springs, may be classed under this division.

6. *Saving time in natural operations*. The process of tanning consists in combining the tanning principle with every particle of the skin, which, by the ordinary process of soaking it in a solution of the tanning matter, requires from six months to two years. By enclosing the solution, with the hide, in a close vessel, and exhausting the air, the pores of the hide being deprived of air exert a capillary attraction on the tan, which may be aided by pressure, so that the thickest hides may be tanned in six weeks. The operation of bleaching affords another example.

7. *Exerting forces too great for human power*. When the force of large bodies of men or animals is applied, it becomes difficult to concentrate it simultaneously at a given point. The power of steam, air, or water is employed to overcome resistances which it would require a great expense to surmount by animal labour. The twisting of the largest cables, the rolling, hammering, and cutting of large masses of iron,

the draining of mines, require enormous exertions of physical force, continued for considerable periods. Other means are used when the force required is great and the space through which it is to act is small. The hydraulic press can, by the exertion of one man, produce a pressure of 1500 atmospheres, or rather more than 20,000 lbs.

8. *Executing operations too delicate for human touch.* The same power which twists the stoutest cable, and weaves the coarsest canvass, may be employed to more advantage than human hands in spinning the gossamer thread of the cotton, and entwining, with fairy fingers, the meshes of the most delicate fabric.

9. *Registering Operations.* Machinery affords a sure means of remedying the inattention of human agents, by instruments, for instance, for counting the strokes of an engine, or the number of coins struck in a press. The tell-tale, a piece of mechanism connected with a clock, in an apartment to which a watchman has not access, reveals whether he has neglected, at any hour of his watch, to pull a string in token of his vigilance.

10. *Economy of Materials.* The precision with which all operations are executed by machinery, and the exact similarity of the articles made, produce a degree of economy in the consumption of the raw material which is sometimes of great importance. In reducing the trunk of a tree to planks, the axe was formerly used, with the loss of at least half the material. The saw produces thin boards, with a loss of not more than an eighth of the material.

11. *The Identity of the Result.* Nothing is more remarkable than the perfect similarity of things manufactured by the same tool. If the top of a box is to be made to fit over the lower part, it may be done by gradually advancing the tool of the sliding rest; after this adjustment, no additional care is requisite in making a thousand boxes. The same result appears in all the arts of printing: the impressions from the same block, or the same copper-plate, have a similarity which no labour of the hand could produce.

12. *Accuracy of the Work.* The accuracy with which machinery executes its work is, perhaps, one of its most important advantages. It would hardly be possible for a very skilful workman, with files and polishing substances, to form a perfect cylinder out of a piece of steel. This process, by the aid of the lathe and the sliding rest, is the every-day employment of hundreds of workmen. On these last two advantages of machinery depends the system of copying, by which pictures of the original may be multiplied, and thus almost unlimited pains may be bestowed in producing the model, which shall cost 10,000 times the price of each individual specimen of its own perfection. Operations of copying take place by printing, by casting, by moulding, by stamping, by punching, with elongation, with altered dimensions. A remarkable example of the arts of copying lies before the eye of the reader in these pages. 1. They are copies obtained by printing from stereotype plates. 2. Those plates are copies obtained (by casting) from moulds formed of plaster of Paris. 3. The moulds are copies obtained by pouring the plaster in a liquid state upon the moveable types. 4. The types are copies (by casting) from moulds of copper, called *matrices*. 5. The lower part of the matrices, bearing the impressions of the letters or characters, are copies (by punching) from steel punches, on which the same characters exist in relief. And, lastly, the cavities in these steel punches, as in the middle of the letters *a*, *b*, &c., are produced from other steel punches in which those parts are in relief.

MACRABIOTICS; the science of prolonging life. Hufeland called his well-known work *Makrabiotik*, or the Art of Prolonging Human Life. (See LONGEVITY.)

MADDER. This plant is much used, on account of the fine scarlet colour afforded by the roots; and, indeed, this substance is essential to dyers and calico-printers, and their manufactures could not be carried on without it. In consequence, it has become an important article of commerce, and is imported into Britain from Holland to a very great extent. Though cultivated in France for a century and a half, the supply is yet inadequate to the consumption in that country, and it is largely imported from the Levant as well as from Holland. Since the extension of manufactures in the United States of America, it has become an object of importance to introduce the culture of madder, and the subject has engaged the attention of several intelligent and public-spirited individuals. The most approved method of culture is from seed; and, where this practice is pursued, certain precautions are requisite. As the madder of hot climates affords more colouring matter, as well as a deeper tint, it is best for those who live in a northern region to import the seed from the south. Again, when the seed is too much dried, it may remain in the ground two or three years before it will germinate. On this account, it should be kept in a bed of moistened earth or sand, whenever there is any delay in sowing it. A light, rich, and deep soil is the most suitable, and it should be ploughed to the depth of two feet. The time of sowing is in February, or the beginning of March, for the more northern, and in September or October for the more southern regions. This kind of crop requires but little care and attention: for the first year it is only necessary to keep it free from the weeds, and to hoe it slightly once during the summer: for the second, it requires hoeing in the spring, in the summer, and again, a little more deeply, in the latter part of the season; the same is requisite for the third year, except that the earth is heaped up about the base of the stems, in order to make them shoot with more vigour, and enlarge the roots. It is usual, before the second time of hoeing, to cut the stems for cattle, who are very fond of it; but this practice should not be repeated during the season, as recommended by some writers, or the roots will suffer. It is only at the end of the third year that the crop is ready for harvesting; but, if it is suffered to remain in the ground beyond this period, more is lost than gained. The roots at this time contain the greatest quantity of colouring matter, and have attained their full size.

The best method of obtaining the roots is the following:—A trench is dug along the rows, to the depth of two feet, when, by loosening the earth about the roots, they may be taken up entire. In a good soil, a single plant may yield forty pounds of the fresh roots, which diminish, in drying, six-sevenths or seven-eighths of their weight. The roots should be immediately washed, freed from all decayed parts, and dried as quickly as possible, either by the sun or in a kiln. It is well observed that madder is a hazardous crop, as, from its yielding a return only after a lapse of three years, it is often impossible to foresee what will be the state of the

market at that time. Another mode of cultivation is from the roots, which are divided and set out: 20,000 plants may be allotted to an acre. In England, the madder from Holland is most esteemed, and it is cultivated in that country to a great extent.

The process of pulverizing the roots, which is done by pounding or grinding, was, for a long time, kept a secret by the Dutch. In the state of a powder, it is of an orange-brown colour, and is liable to become damp, and to be spoiled, if kept in a moist place. Madder is used for dyeing woollen, silk, and also cotton goods: the colour is very lasting, and resists the action of the air and sun. Within a few years, a method has been discovered of rendering the red exceedingly brilliant, and approaching to purple. It also forms a first tint for several other shades of colour, and, besides, has of late been successfully used by painters, and is found to yield a fine rose colour. Madder possesses the singular property of imparting its red colour to the bones of those animals which have used it for food, and also to the milk of cows, if they have eaten of it freely.

Composition of Madder, and its employment in Dyeing. All the parts of the plant contain a yellow colouring matter, which, by absorption of oxygen, becomes red; the root is, however, most productive in this colouring matter, and is the only part employed in dyeing. It is distinguished into three parts—the bark, the middle portion, and the interior woody fibre. The bark contains the same colouring matter as the wood, but mixed with much brown extractive matter, which injures the hue. The bark may be separated in the milling; for it is more readily ground, and may thus be removed by the sieve. In the middle part of the root, which contains the finest colouring matter, and that in largest quantity, there may be distinguished by the microscope a great many shining red particles, dispersed among the fibres. These constitute the rich dyeing material. The fibres contain a brown substance, similar to what is found in bark. The roots occur in commerce dried and in powder. They are also sold fresh, in which state they yield finer colours, dye more, and give up their colouring matter with one-third less water. According to experiments made in this country, four pounds of fresh roots go as far as five of the dry ones; and it is estimated that eight pounds of fresh roots are reduced to one in drying; hence the great advantage of using the green roots becomes apparent.

The madders of Germany and Holland are orange-yellow, passing into brown red, having an acid and saccharine taste, and a strong smell. A distinguished chemist found, in 100 parts of madder,

Fatty matter, of a red-brown colour, resembling wax	1.0
Red resinous matter	3.0
Red extractive matter	20.0
Oxidized extractive	5.0
Brownish gum	8.0
Ligneous fibre	43.5
Acetate of potash and lime	8.0
Phosphate, muriate, and sulphate of potash, about	2.0
Silica	1.5
Oxide of iron	0.5
Waste	7.5
	100.0

According to other analyses, madder contains free tartaric acid. Kuhlmann finds, in the madder of Alsace, red colouring matter, dun colouring matter, ligneous fibre, vegetable acids, mucilage, vegeto-animal matters (azotized), gum (four per cent.), sugar (sixteen per cent.), bitter matter, resin, salts: the last consist of carbonate, sulphate, and muriate of potash, carbonate and phosphate of lime, with silica.

The researches of MM. Robiquet, Colin, and Kuhlmann, seem to prove that the differences in the madder dyes proceed from the relative proportions of two distinct colouring principles in madder, which they have called *alizarine* and *xanthine.* By digesting the powder of madder in water, and acting upon the jelly-like solution thus obtained by boiling alcohol, an extract is afforded, which, at a subliming heat, yields the proper red colouring matter of madder, or alizarine. Or the ground madder may be treated directly with boiling alcohol, and dilute sulphuric acid added to the alcoholic solution, which will throw down the alizarine in a copious orange precipitate. Alizarine has a golden-yellow hue, is insoluble in water, but soluble in alcohol and ether: it is precipitated by acids, but not by alkalies, showing distinctly an analogy to resins. The xanthine was obtained from a fawn-yellow matter, soluble in alcohol and water, by precipitation with oxide of lead, washing the precipitate with alcohol, and extricating the colour by sulphuric acid. It has an orange-green tint, and a saccharine taste; alkalies cause it to pass into red, and acids to lemon-yellow. It is inferred by these chemists that in those fabrics which exhibit rose-tints the xanthine predominates, while in the violet it is nearly wanting. From a knowledge of these facts, it becomes easy for a skilful dyer to promote the absorption, by the cloth, of one or other of these colouring principles, or to remove one of them, should both together have been attached to it.

Kurrer has published, in the *Polytechnic Journal* of Dingler for 1827, a process, by a spirituous or vinous fermentation, and an immediate subsequent washing, which gives a perfect result with all the madders of commerce. The madder, penetrated with water, and covered over merely one inch, ferments in from thirty-six to forty-eight hours, when the whole is transferred into a tub containing a considerable quantity of cold water. Here the madder precipitates, and must be washed with several cold waters. The ordinary madder-red dye is given in the following way:—The yarn or cloth is put into a very weak alkaline bath, at the boiling temperature, then washed, dried, and galled; or, when the calico is to be printed, for this bath may be substituted one of cow-dung, subsequent exposure to the air for a day or two, and immersion in very dilute sulphuric acid. In this way the stuff becomes opened, and takes and retains the colour better. After the galling, the goods are dried, and alumed twice; then dried, rinsed, and passed through the madder-bath. This is composed of three-quarters of a pound of good madder for every pound weight of the goods. The bath is slowly raised to the boiling point in the course of fifty or sixty minutes, more or less, according to the shade of colour wished for. When the boiling has continued for a few minutes, the stuff is taken out, washed slightly, and dried a second time in the same manner, and with as much madder. It is then washed and dried, or passed through a hot soap-bath, which carries off the fawn-coloured par-

ticles. Other dyes likewise are added to the madder-bath, to obtain other shades of colour; for instance, a decoction of fustic, weld, logwood, or quercitron, the mordants being modified accordingly. Hoelterhoff prescribes for *ordinary madder-red* the following proportions:—twenty pounds of cotton yarn, fourteen pounds of Dutch madder, three pounds of gall-nuts, five pounds of alum; to which are added, first, a pound and a half of acetate of lead, and, subsequently, a quarter of a pound of chalk. When bran is added to the madder-bath, the colour becomes much lighter, and of a more agreeable tint.

Adrianople madder-red is given by many distinct operations. The first consists in cleansing or scouring the goods by alkaline baths, after which they are steeped in oily liquors, and brought to a creamy state by a little carbonate of soda solution. Infusion of sheep's dung is often used as an intermediate or secondary steep. The operation of oiling, with much manual labour, and then removing the superfluous or loosely-adhering oil with an alkaline bath, is repeated two or three times, taking care to dry hard, after each process. Then follows the galling, aluming, maddering, and brightening, for removing the dun-coloured principle, by boiling at an elevated temperature, with alkaline liquids and soap.

MAGELLANIC CLOUDS; whitish appearances, like clouds, seen in the heavens towards the south pole, and having the same apparent motion as the stars. They are three in number, two of them near each other. The largest lies far from the south pole; but the other two are about 11° distant. They may be multitudes of stars, like the milky way.

MAGIC. Men, as soon as they began to observe the phenomena around them, could not help seeing the close connexion which exists between man and external nature. When the sun sets, he wants rest, and sleep approaches with night; atmospheric changes affect his health; certain wounds become painful with the change of weather, or at certain phases of the moon; some men are painfully affected in the presence of particular animals; certain liquids exhilarate, others destroy life. Such and similar observations, combined with many of an erroneous and exaggerated character, springing from credulity and ignorance, soon led men to treat this mysterious connection of man and nature, and the influence of things or causes without him upon his mind and body, as a peculiar science, which, when occupations were not yet divided, of course belonged to the priests, whose exclusive possession of knowledge made them the guides of men in science and the arts as well as in religion. This is considered, by some, the natural origin of supernatural magic; others, on the contrary, believe that there once actually existed a deeper knowledge of the powers and influences of nature, transmitted from earlier and purer ages, but lost with increasing folly and guilt; and others believe that men once possessed the means of producing supernatural effects with the assistance of evil spirits, as those particularly gifted by Providence were able to produce supernatural effects with the assistance of God.

Media, Persia, and the neighbouring countries, famous for their knowledge of astronomy and astrology, are described as the chief seats of the ancient magi, whose doctrine seems to be, in part, of great antiquity. This doctrine represented opposition or strife as the parent and original cause of all things. After the opposition between light and darkness (Ormuzd and Ahriman) was established, the whole series of finite beings, the whole sensual world, proceeded from this constant struggle of light and darkness, good and evil. The change of day and night, light and darkness, the whole series of ages, time itself, is only a consequence of this struggle, in which sometimes light, sometimes darkness, appears victorious, until finally light shall conquer for ever. If all finite things stand under the influence of preserving and destroying powers in nature, it is clear that he who could master these powers could dispose, at his pleasure, of the things subject to them; and the doctrine of the Magians was, that by prayer and a true knowledge of those laws of opposition, love and hatred, light and darkness, such power could be obtained; and that thus, also, it was possible to search into futurity. But it was believed that as the world became sinful the light of the ancient doctrine of the magi was obscured, and those who bore the name became, at last, only evil-disposed sorcerers. One important branch of their art was the excitement of love by potions and enchantments. Their love-potions consisted partly of ingredients which are still known to physicians as stimulants, and partly of parts of animals which had died longing for food or air. Magic, at this period, also occupied itself with fortune-telling, calling up the dead, bewitching by the look, or evil eye (a superstition which we find existing in the processes against witches in modern times), with the preparation of amulets, the inflicting of pain on a person by correspondent applications to his image in wax, &c. He who wishes to become acquainted with the poetical side of magic ought to read the Arabian Nights. It can hardly be doubted that the art of the ancient magicians was founded, to a considerable degree, upon a superior knowledge of the powers of nature. The name of the magnet, *magnes*, or *enchanting stone* (according to one derivation), seems to indicate that it was not unknown to the magi; and some of their phenomena seem referrible to galvanism.

MAGNESIA; one of the earths, having a metallic basis called *magnesium*. It exists in nature, under various states of combination, with acids, water, and other earths, and is found in various mineral springs, and the water of the ocean, united with sulphuric and muriatic acids. It may be obtained by pouring into a solution of its sulphate a solution of subcarbonate of soda, washing the precipitate, drying it, and exposing it to a red heat. It is usually procured in commerce by acting on magnesian limestone with the impure muriate of magnesia, or bittern of the sea-salt manufactories. The muriatic acid goes to the lime, forming a soluble salt, and leaves behind the magnesia of both the bittern and the limestone; or the bittern is decomposed by a crude subcarbonate of ammonia, obtained from the distillation of bones in iron cylinders. Muriate of ammonia and subcarbonate of magnesia result. The former is evaporated to dryness, mixed with chalk, and sublimed. Subcarbonate of ammonia is thus recovered, with which a new quantity of bittern may be decomposed. 100 parts of crystallized Epsom salt require, for complete decomposition, fifty-six of subcarbonate of potash, or forty-four of dry subcarbonate of soda, and yield sixteen of pure magnesia after calcination. Magnesia dissolves very sparingly in water, requiring 5142 times its weight of water at 60°, and 36,000

of boiling water, for solution. The resulting liquid does not change the colour of violets; but when pure magnesia is put upon moistened turmeric paper it causes a brown stain. It possesses the still more essential character of alkalinity in forming neutral salts with acid in an eminent degree. It absorbs both water and carbonic acid when exposed to the atmosphere. It is infusible, except in the intense heat of the compound blow-pipe. The salts of magnesia are in general very soluble, and crystallizable, and possessed of a bitter taste. The *carbonate* is prepared for medicinal use, by dissolving equal weights of sulphate of magnesia and carbonate of potash, separately, in twice their weight of water; mixing them together, and diluting with eight parts of warm water; the magnesia attracts the carbonic acid, and the compound, being insoluble, is precipitated, while the sulphate of potash that remains continues in solution. The mixture is made to boil for a few minutes; after cooling a little it is poured upon a filter; the clear fluid runs through, and the precipitate or carbonate of magnesia is washed with water till it is tasteless. When the process is conducted on a large scale, the bittern, or liquor remaining after the crystallization of sea-salt, which is principally a solution of muriate and sulphate of magnesia, is substituted for the pure sulphate, and this is precipitated by a solution of pearlash or of carbonate of ammonia. Carbonate of magnesia is perfectly white, friable, and nearly tasteless. It is very sparingly soluble in water, requiring at least 2000 times its weight at 60°. When acted on by water impregnated with carbonic acid, it is dissolved; and from this solution, allowed to evaporate spontaneously, the carbonate of magnesia is deposited in small prismatic crystals, which are transparent and efflorescent.

Nitrate of magnesia has a bitter and acrid taste. Its crystallization exhibits a mass of needle-like crystals, deliquescent, soluble in half their weight of water at 60°.

Sulphate of magnesia, generally known by the name of *Epsom salt*, is made directly by neutralizing dilute sulphuric acid with carbonate of magnesia; but in the large way by the action of dilute sulphuric acid on magnesian limestone, and the native carbonate of magnesia. It is possessed of a saline, bitter, and nauseous taste. It crystallizes readily in small quadrangular prisms, which effloresce in a dry air. It is obtained also in larger six-sided prisms, terminated by six-sided pyramids. Its primary form is a right rhombic prism, the angles of which are 90° 30′ and 89° 30′. It is soluble in an equal weight of water at 60°, and in three-fourths of its weight of boiling water. It undergoes the watery fusion when heated. On mixing solutions of sulphate of magnesia and sulphate of potash in atomic proportion, and evaporating, a double salt is formed, which consists of one equivalent of each of the salts and six equivalents of water. A similar double salt is formed by spontaneous evaporation from the mixed solutions of sulphate of ammonia and sulphate of magnesia.

Phosphate of magnesia, formed from the combination of the acid and the earth, crystallizes in prisms, which are efflorescent, soluble in about fifteen parts of cold water, and which, by heat, melt into a glass.

A *triple phosphate of magnesia and ammonia* exists, which is formed by adding phosphoric acid with ammonia, in excess, to a magnesian salt. It is insoluble, and is precipitated in a soft white powder of shining lustre. It forms one variety of urinary calculi, and its formation affords one of the best tests for the discovery of magnesia.

Muriate of magnesia has such an affinity to water that it can be obtained in acicular crystals only by exposing its concentrated solution to sudden cold. No chloride of magnesium can be obtained by heating this salt; for the acid is expelled from it undecomposed, by the application of heat.

Chloride of magnesia may be formed in the same manner as chloride of lime. It has the same bleaching power, and it has been proposed to apply it to the same purpose. When the chloride of lime is used, a small quantity of lime is left on the cloth: this, in the last operation of washing the cloth with water acidulated with sulphuric acid, is converted into sulphate of lime, which, being insoluble, remains, and affects the colours, when the cloth is dyed. The advantage of employing the chloride of magnesia is, that, if sulphate of magnesia be formed, it is so soluble as to be easily removed by washing. Magnesia is a very useful article of the *materia medica*. It is used as an antacid and cathartic. It is however nearly inoperative, unless there is acid in the stomach, or unless acid is taken after it. The carbonate and sulphate are the most frequently used of the preparations of magnesia; but the pure earth, sold under the name of *calcined magnesia*, is sometimes preferred; it is liable, however, to form large and dangerous accumulations in the bowels, of several pounds weight, when its use has long been persevered in.

MAGNETISM. This science may justly be considered as yet but in its infancy, although the facts elicited since the commencement of the nineteenth century, by Barlow, Morichini, Faraday, and Davy, bid fair to throw considerable light on some of its more recondite principles.

The theory of magnetism bears a very strong resemblance to that of electricity. We have seen the electric fluid not only exerting attractions and repulsions, and causing a peculiar distribution of the neighbouring portions of a fluid similar to itself, but also excited in one body and transferred to another in such a manner as to be perceptible to the senses, or at least to cause sensible effects, in its passage. The attraction and repulsion, and the peculiar distribution of the neighbouring fluid, are found in the phenomena of magnetism; and we now perceive an actual excitation or perceptible transfer of the magnetic fluid from one body to another: it has also this striking peculiarity, that metallic iron is very nearly the only substance capable of exhibiting any strong indications of its presence.

The most simple experimental illustration of the effects of magnetic attraction may be thus shown. If the north pole of a magnetized bar be presented to a similar pole of another bar, it will be repelled or driven away from it; but if, on the contrary, two opposite poles be presented towards each other, they will be attracted.

From this it will be seen that a north pole always repels a north pole, and attracts a south pole. And, if a neutral piece of soft iron be brought near to the north pole of a magnet, the fluid will become so distributed by induction as to form a temporary south pole next to the magnet, and the whole piece will of course be attracted, from the greater proximity of the attracting pole. If the bar is sufficiently soft, and not

too long, the remoter end becomes a north pole, and the whole bar a perfect temporary magnet. But, when the bar is of hard steel, the state of induction is imperfect, from the resistance opposed to the motion of the fluid; hence the attraction is less powerful, and an opposite pole is formed at a certain distance within the bar, and beyond this another pole, similar to the first, the alternation being sometimes repeated. The distribution of the fluid within the magnet is also affected by the neighbourhood of a piece of soft iron, the north pole becoming more powerful by the vicinity of the new south pole, and the south pole being consequently strengthened in a certain degree; so that the attractive power of the whole magnet is increased by the proximity of the iron. A weak magnet is capable of receiving a temporary induction of a contrary magnetism from the action of a more powerful one, its north pole becoming a south pole on the approach of a stronger north pole; but the original south pole still retains its situation at the opposite end, and restores the magnet nearly to its original condition, after the removal of the disturbing cause.

To explain the phenomena of magnetism, Æpinus suggested the following hypothesis. He imagined that there must exist a fluid capable of producing all the phenomena of attraction and repulsion, and with a subtilty so great as to penetrate the pores of all bodies; and also of an elastic nature, its particles being repulsive of each other. At the same time he imagined a mutual attraction between the magnetic fluid and iron, or other ferruginous bodies. According to this hypothesis, iron and all ferruginous substances contain a quantity of magnetic fluid which is equally dispersed through their substance, when those bodies are not magnetic; in which state they show no attraction or repulsion towards each other, because the repulsion between the particles of the magnetic fluid is balanced by the attraction between the matter of those bodies and the said fluid, in which case those bodies are said to be in a natural state; but, when in a ferruginous body the quantity of magnetic fluid belonging to it is driven to one end, then the body becomes magnetic, one extremity of it being now overcharged with magnetism and the other extremity undercharged. Bodies thus modified, or rendered magnetic, exert a repulsion between their overcharged extremities, in virtue of the repulsion between the particles of that excess of magnetic fluid, which is more than overbalanced by the attraction of their matter. There is an attraction exerted between the overcharged extremity of one magnetic body and the undercharged extremity of the other, on account of the attraction between that fluid and the matter of the body; but, to explain the repulsion which takes place between their undercharged extremities, we must either imagine that the matter of ferruginous bodies, deprived of its magnetic fluid, must be repulsive of its own particles, or that the undercharged extremities appear to repel each other, only because either of them attracts the opposite overcharged extremities, both which suppositions are embarrassed with difficulties. A ferruginous body, therefore, is rendered magnetic by having the equable diffusion of the magnetic fluid throughout its substance disturbed, so as to have an overplus of it in one or more parts, and a deficiency of it in the remainder, and it remains magnetic as long as its impermeability prevents the restoration of the balance between the overcharged and undercharged parts.

The distinction between conductors and non-conductors is, with respect to the electric fluid, irregular and intricate: but in magnetism the softness or hardness of a ferruginous body constitutes the main distinction. And it is well known that magnetic effects are produced by quantities of iron incapable of being detected either by their weight or the most delicate chemical tests. M. Cavallo found that a few particles of steel, adhering to a hone on which the point of a needle had been slightly rubbed, imparted to it magnetic properties; and M. Coulomb has observed that there are scarcely any bodies in nature which do not exhibit some marks of being subjected to the influence of magnetism, although its force is generally proportional to the quantity of iron which they contain, as far as that quantity can be ascertained. Dr. Young considers a single grain sufficient to make twenty pounds of another metal sensibly magnetic.

The *loadstone*, or natural magnet, is a heavy iron ore, and is found in large masses in every quarter of the globe.

Three very large loadstones have been brought from Moscow to this country, and an account of them read before the Wernerian Society, by Mr. Deuchar. The largest of these natural magnets weighs more than 125 lbs., and measures in length ten inches and three quarters, in breadth eight and a half, and in height nine inches and a half. When first examined it supported 163 lbs.; but, by gradually increasing the weight, it was afterwards brought to support 165 lbs., exclusive of a connecting iron and supports of 40 lbs. The weight of the second loadstone had not been taken previous to fitting on the armature, but it was supposed to be nearly half that of the large one, and it supported above 80 lbs. These natural magnets were brought to this country in the same vessel, and it appeared probable that the corresponding poles had been placed together, as those of the weakest had been reversed.

There are some important circumstances which require attention, in order to enable us to ascertain the best method of constructing artificial magnets.

The nature of the body must be adapted to the power which is to render it magnetic; remembering that soft ferruginous bodies both acquire and lose magnetism more easily than those which are harder.

Several magnets are much preferable to a single one, for the purpose of communicating magnetism, in the application of which it must be remembered that the south pole of the magnet produces a north pole in the part of the ferruginous body to which it is first applied, while the north pole of the magnet produces a south pole.

If it be required to construct a strong magnet, when the operator has either no magnet at all or a very weak one, he must proceed gradually. It being impossible for a hard and large steel bar to receive any sensible degree of magnetism from the action of the earth, or of any other weak magnet, the operator must begin with giving magnetism to several small and soft steel bars, impregnating one at a time by means of the weak magnet, or, if he have no magnet, by means of one or more iron rods properly situated, which in that case are real though weak magnets. Then, by joining in a proper manner the small steel

bars already made magnetic, he may communicate a stronger power to larger and harder steel bars.

Should the experimentalist possess several magnets, he may materially facilitate the process by adopting the arrangements represented at *figs.* 1 and 2, *Plate* I., MAGNETISM. In the first figure four bars may be magnetized by two possessing the magnetic influence. These are to be drawn, with their opposite poles in succession, over the former series, commencing in the centre. In the second arrangement double sets of bars are used, forming a species of horse-shoe magnet; and the weight and mass of iron serve the double purpose of steadying the bars and increasing the facility with which they acquire magnetism.

Mr. Michell's method of making magnets may be thus described:—Prepare a dozen bars of steel, of about an ounce and three quarters weight each, six inches long, and half an inch broad: let these be hardened by immersion into water at a red heat. The size and shape of the bars may be varied at pleasure, provided that the length be proportioned to the thickness. The best sort of steel is that which has no veins of iron in it, and Mr. Michell found the common blistered steel at least equal to any other. In order to preserve the bars, they must be placed in a box furnished with two pieces of iron, about an inch long each. These pieces of iron may be about a quarter of an inch square, and should be filed perfectly smooth on the sides. Against these are to be placed, with their edges towards them, the twelve magnetical bars, six on one side, with their south or north poles one way, and six on the other side, with the same poles the contrary way. It is necessary to observe that these bars should be introduced in pairs, or single magnets on either side; for if two only be left with their poles of the same denomination the same way, without one or more on the other side to counterbalance their effects, they will injure each other. In order to make the marked ends of these bars south poles, and the other ends north poles, place six of them in a line north and south, bringing the unmarked end of one to touch the marked end of the next throughout, the marked ends lying towards the north, which will be some advantage to them. Then take an armed magnet, and placing it with both poles upon one of the bars, the north pole towards the marked end, which is to be a south pole, and the south pole towards the unmarked end, which is to be a north pole, slide it backwards and forwards from end to end of the whole line of bars three or four times, taking care that they all touch. Then, taking it off, remove the two endmost bars into the middle, and pass over them again three or four times. Having thus touched the bars, it will not be improper to turn them with the other side uppermost, and to magnetize again on that side as before, omitting the endmost bars, till they are removed into the middle, when they must undergo the same process.

Professor Steinhauser has ascertained that if by the process of Canton we unite, in the form of a square, two steel bars, and two contacts of iron, it is better to operate by the double touch in a circle than by a motion backwards and forwards. Again, when we combine these bars in a square, the force of that which we wish to magnetize ought to increase in proportion as the other magnet has become more energetic. In magnetizing horse-shoe magnets, it is much more advantageous to place two of these bent bars with their friendly poles so situated as that the magnetic circle be completed; and that we should then touch circularly, with the magnet destined to communicate the power. When the two horse-shoe bars are separated, they lose usually a considerable part of their force, if we do not previously decompose the great circuit into two smaller ones, by applying each contact to its curved magnet before the separation. In this way, the two separated magnets lose little or nothing of their power; and two may be touched in the same time that one is on the usual plan. By conforming to these rules, Professor Steinhauser has succeeded in making magnets of extraordinary power, in the least possible time.

Among artificial magnets, those which are bent into such a form that the two ends nearly meet, and therefore called horse-shoe magnets, are reckoned the most powerful. To render such a shaped piece magnetic, place a pair of magnetized bars against the ends of the horse-shoe, with the south end of the bar against that of the horse-shoe which is intended to be north, and the north end of the bar to that which is to be the south, the lifter, of soft iron, to be placed at the other end of the bars: also rub the surfaces of the horse-shoe with the pair of bars disposed like the legs of compasses when a little open, or with another horse-shoe magnet, turning the poles properly to those of the proposed magnet, and being careful that these bars never touch the ends of the straight bars. To prevent a sudden separation of the bars from the horse-shoe, which would considerably diminish the force of the latter, slide on the lifter, or support, to the end of the horse-shoe magnet, but in such a manner that it may not touch the bars; they may then be taken away, and the support slid to its place.

The following mode of making strong magnets, by percussion, was invented by Captain Scoresby, and published in the Philosophical Transactions for 1822. He observes—"The strong magnetizing effects of percussion on soft steel induced me to apply this property to the formation of magnets. For this purpose, I procured two bars of soft steel, thirty inches long and an inch broad; also six other bars of soft steel, eight inches long and half an inch broad, and a large bar of soft iron. The large steel and iron bars were not, however, absolutely necessary, as common pokers answer the purpose very well; but I was desirous to accelerate the process by the use of substances capable of aiding the developement of the magnetical properties in steel. The large iron bar was first hammered in a vertical position; it was then laid on the ground, with its acquired south pole towards the south; and, upon this end of it, the large steel bars were rested while they were hammered; they were also hammered upon each other. On the summit of one of the large steel bars, each of the small steel bars, held also vertically, was hammered in succession; and, in a few minutes, they had all acquired considerable lifting powers. Two of the smaller bars, connected by two short pieces of soft iron, in the form of a parallelogram, were now rubbed with the other four bars in the manner of Canton. [This process is, to take two of the four bars, and place them together so as to make a double bar in thickness, the north pole of one even with the south pole of the other, the remaining two being put to these, one on each side, so as to have two north and two south poles together. Separate the north pole from

the south pole at one end by a large pin, and place the bars perpendicularly, with that end downwards, on the middle of one of the parallel bars, the two north poles towards the south, and the two south poles towards its north end; slide them backward and forward three or four times the whole length of the bar, and, removing them from the middle of this, place them on the middle of the other bar, as before directed, and go over that in the same manner; then turn both the bars the other side upwards, and repeat the former operation. This being done, the two bars that have been thus treated are to change places with two of the touching bars, which are to be subjected to the same process, and so with the two other touching bars.] These were then changed for two others, and these again for the last two. After treating each pair of bars in this way a number of times, and changing them whenever the manipulations had been continued for about a minute, the whole of the bars were at length found to be magnetized to saturation, each pair readily lifting above eight ounces. In accomplishing this object, I took particular care that no magnetic substance was used in the process. All the bars were freed of magnetism before the experiment, so that none of them, not even the largest, produced a deviation of five degrees on the compass at three inches distance. Any bars which had been strongly magnetized, and had had their magnetism destroyed or neutralized (either by hammering, heating, or by the simultaneous contact of the two poles of another magnet placed transversely), I always found had a much greater facility for receiving polarity in the same direction as before than the contrary. Hence it generally happened that one blow with the original north end downwards produced as much effect as two or three blows did with the original south end downward." The correspondence between magnetism and electricity, in many of their phenomena, has, as we have already stated, led philosophers to refer both to a common principle.

The power of a magnet, and of iron or steel impregnated with the magnetic virtue, may be impaired by long lying in a wrong position, with regard to the earth or with respect to each other. Thus, if two magnets be placed so that their contrary poles may be contiguous, they will preserve one another's power; but if the north pole of one be placed near the north pole of the other, and the south near the south, then they will entirely destroy, or diminish each other's magnetism; and, if their original powers were very unequal, the polarity of the weaker magnet will be changed by the action of the stronger one.

In general, the same means which facilitate the communication of magnetism, when pieces of iron, &c., are properly situated with respect to the poles of the earth, or of other magnets, will likewise facilitate the loss of magnetism when the magnets are improperly situated; thus a red heat destroys in a great measure, or entirely, the power of a magnet. A steel bar, strongly magnetic, will have its power much diminished by being repeatedly struck between two stones, especially if it be struck standing in a direction perpendicular to the magnetic meridian. A bar of hard iron, which has acquired some degree of permanent magnetism, by being made red-hot and then cooled in the direction of the magnetical line, will have that power destroyed, or much diminished, by a few blows on its middle.

The directive power of a magnet is extended to a greater distance than its attractive power; for instance, if a magnet be freely suspended, another magnet properly situated within a certain distance of the former will turn it out of its ordinary direction; yet the degree of attraction exerted by these magnets against each other is not sensible at that distance, which may be easily tried by fixing one of the magnets to the scale of a balance. The reason of this property is, that the directive power depends both upon the attraction of the poles of different names and on the repulsion of those of the same name; whereas the attraction takes place only between poles of different names. In order to render this view of the matter more intelligible, we may imagine a magnetic needle freely suspended, and placed within the influence or sphere of action of a magnet. In this disposition, suppose that the north pole of a magnet attracts the south pole of a magnetic needle with a force equal to ten grains, and, as the attraction between poles of different names is nearly equal to the repulsion between poles of the same name, it follows that the same north pole of the magnet repels the north pole of the magnetic needle with a force equal to ten grains: but these two forces both concur in altering the direction of the needle; therefore, the endeavour of the magnet to turn the needle's direction is equal to twenty grains; whereas the attraction, or the force by which the needle is drawn towards the magnet, is only equal to the difference between the two above-mentioned opposite forces, which difference arises from the pole of the magnet being nearer to one than to the other of the poles of the needle. The same reasoning may be applied to the action between the south pole of the magnet and the suspended needle.*

The most remarkable phenomenon of the magnet, in relation to the earth, is the variation of the magnetic meridian in most parts of the globe, upon which depends the declination of the needle. Accurate observation of this phenomenon has ascertained the following facts:—There are certain points on the earth where no declination exists. The lines formed by their series, however, do not coincide with the geographical meridians; but, on the contrary, deviate from them very irregularly. According to the most recent observations, there exists a line without declination in the Atlantic Ocean, between the old and the new world. It intersects the meridian of Paris at a southern latitude of about 65°; thence it mounts to the north-west, to about 35° west longitude from this meridian, or 32° 39′ 37″ from Greenwich, as high as the latitude of the coast of Paraguay; after which, becoming again almost north and south, it skirts the coast of Brazil, and proceeds to the latitude of Cayenne. Then, turning suddenly to the north-west, it takes the direction of the United States of America, and thence proceeds to the northern parts of that continent, which it traverses in the same direction. The position of this line on the globe is not immutable; at least for a century and a half it has been tending considerably from the east to the west. It passed London in 1657, and Paris in 1664. Thus, in its present direction, it has traversed in the latitude of these places nearly 80° of longitude in 150 years. But there is no doubt that this change is not uniform. It is even very unequal in different parallels. In the

* See "*Manual of Natural Philosophy*," by the Editor of this work.

West Indies, for example, the declination of the needle has hardly varied for 140 years. In general, the slowness of this movement leaves it uncertain whether it is constantly progressive or whether it must continue in any particular direction. The very accurate observations habitually made in several observatories of England and France have appeared to indicate, for some years, a commencing retrogradation towards the east; but, even in the years 1790 and 1791, a similar retrogradation had been observed, which did not, however, continue.

The very exact measures of the inclinations or dip of the needle made at different periods, by Gilpin and Cavendish, in London, have proved that this element is also variable, though much less so than the declination. The inclination was, at London, in 1775, 72° 30′; in 1805, 70° 21′. This result has been confirmed in France, by the observations of Humboldt. It has been also proved, in a still more striking manner, by the successive measures of the inclination made by different navigators, between 1751 and 1792, at the Cape of Good Hope, which indicate, during this time, a progressive increase of inclination amounting to 5°. There is another line without declination, almost opposite to the preceding, which beginning in the great Southern Ocean, and running constantly in a north-western direction, cuts the western point of New Holland, traverses the Indian Ocean, enters the continent of Asia at Cape Comorin, and thence, passing through Persia and Western Siberia, ascends to Lapland. This line, however, divides near the great archipelago of Asia, and gives rise to another branch, which, running almost directly north and south, passes this archipelago, crosses China, and runs into the eastern part of Siberia. The two branches which intersect this line either experience no change of place or move with much slowness. The declination of the needle does not appear to have varied sensibly for 140 years at New Holland. Indications of a fourth line without declination were observed by Cook in the South Sea, towards the point of greatest inflexion of the magnetic equator. On the other hand, the points where the greatest declination of the needle has been observed are in high latitudes north and south. The greatest observed by Cook in the southern hemisphere was at 60° 40′ of latitude, and 91° 24′ 37″ west from Greenwich. In the northern hemisphere, where the magnetic pole has been much more nearly approached, much greater declinations have been observed, amounting, in fact, to nearly 90° west. If the magnetic pole had been crossed, the north pole of the needle would have been turned to the south, and, directly over the pole, its direction would have been vertical, and of course it would have had no horizontal direction. It appears, therefore, that the horizontal direction will be very weak when the dip or inclination is great; so that a very slight extraneous influence, such as the iron on ship-board, may render the compass useless.

Besides these variations, others occur daily, and others according to the seasons. From eight o'clock A.M., the declination increases until about three o'clock; then it decreases until eight o'clock P.M., and remains unaltered until eight A. M. The amount of these daily deviations is the greatest from April to July, when it is from 13′ to 16′; in the other months, it is from 8′ to 10′. The direction of the needle is said to be affected by approaching earthquakes, or eruptions of volcanoes. If a needle stands in the magnetic meridian, and is displaced by foreign power, it returns, when the power ceases to act, to its former situation by a series of oscillations. The time of an oscillation, in the case of the same needle, has a certain relation to the magnetic power of the earth, and serves as a measure of it, in a similar way as the oscillations of the pendulum serve for the measurement of the degrees of gravity. Humboldt found that a needle which, in Paris, made 245 oscillations in ten minutes, made, in Peru, but 211 in the same time, which would give the proportion of the magnetic power of the earth at Paris to that in Peru nearly as 135 : 100. On the other hand, according to Gay-Lussac, an elevation of 3532 toises (about 22,600 feet) over the level of the sea (in a balloon) showed no influence upon the magnetic power. The number of the oscillations, and of course the intensity of the magnetic power of the earth, always diminish in approaching the magnetic equator and increase in approaching the magnetic pole.

Another remarkable and evident manifestation of the influence of the magnetism of the earth upon the needle is the inclination or dip of the latter; i. e. a deviation from the horizontal plane, in northern regions of the north pole of the magnet, in the southern regions of the south pole of the magnet, and which, in the region of the magnetic equator, is 0, but increases towards the poles. This phenomenon, also, is subject to differences, because the magnetic equator of the earth cuts the terrestrial equator, and winds through it in a serpentine line, in which it reaches twice on each side its maximum of distance from the earth's equator, which is nowhere more than 40° 10′. The inclination, in the northern hemisphere of the earth, is the strongest between 70° and 80° latitude. Under 74° 47′, where Parry remained during the winter, the inclination amounted to 88° 43′ 45″. The cause of all these phenomena is as yet unexplained. That there are great magnets in the earth, which move periodically, or (according to Professor Steinhauser) that an interior planet (Minerva) revolves round the centre of the earth once in 440 years, and thus produces the magnetic phenomena on the surface, or that (as Sander supposes) these are to be ascribed to a magnetic planet on the other side of Herschel, completing a revolution only once in 1720 years, may be matter of interesting speculation, but can hardly be looked on as any thing more.

It had long been doubted whether any real analogy could be traced between light and magnetism; that problem is now, however, solved by Dr. Faraday's experiments. The only apparatus which serves to show on a large scale the identity which exists between light and magnetism is now placed in the National Gallery of Practical Science. It is delineated in *figs.* 3 and 4, *Plate* II., MAGNETISM, and the same letters refer to both figures. This instrument is of the horse-shoe form, and is composed of twelve sheer-steel plates, *aa*, each twenty-eight inches in length from the poles to the centre edge. At the greatest width of the curve the horse-shoe is seven inches across, and the extremities of the poles, *b*, *c*, are an inch and a half asunder. The keeper, or lifter, *d*, which is made of the purest soft iron, is five inches in length, two inches and a half wide, and one inch thick. Around the middle of the keeper, and occupying with its lower section the space between the poles, is a wooden winder, having about 100 yards of common threaded bonnet-wire, from which the

two ends, *e, f*, composed of four lengths of the wire twisted together, are carried out. One of the twisted ends passes beyond each end of the keeper, and rests upon the respective poles of the magnet *b, c*. A short lever, *g*, placed in a frame, is so attached to the winder and keeper as to admit of their being forced up by the hand applied to the longer end of the lever. Every time this is effected a brilliant coruscation of light is produced at the end of the wire. The sparks thus elicited will ignite inflammable bodies, and the whole experiment proves to a demonstration the intimate analogy which exists between light, magnetism, and heat.

Under the article ELECTRO-MAGNETISM our readers will find a series of experiments intended to illustrate the phenomena which result from combining voltaic electricity with the magnetic powers. We now revert to the subject to point out a mode of preparing a horse-shoe magnet of prodigious powers from a piece of common soft iron. The apparatus we are about to describe is the only one yet constructed on so large a scale, combining a perfect scientific arrangement with enormous magnetic power. It is represented at *figs*. 1 and 2, *Plate* II., MAGNETISM, and consists of a bar of soft iron bent into the form of a horse-shoe, and weighing about thirty-four pounds: it is surrounded with systematic reduplications of copper wire. There are ten series of the wire, each containing ninety feet. The commencing extremities are all soldered to a thick wire, *b*, while those terminating are likewise affixed to another wire, *c*. This arrangement affords the means of transmitting an electric current through the whole series of wires at the same time with great facility. The voltaic battery, *d*, employed to make the magnet, is very small, and composed of a double concentric cylinder of copper, and a movable cylinder of zinc, *e*. By the aid of this apparatus the horse-shoe of soft iron may in an instant be converted into a magnet capable of supporting a weight of 500 lbs. attached to the scale *f*, beneath. The whole is supported by a strong triangular stand, *g*.

The compass furnishes a most important application of magnetism to practical science. A common compass, in its early form, is delineated at *fig*. 4, *Plate* I., MAGNETISM. It consisted of a cylindrical box, *b*, supported by two centres or pivots resting in the uprights *h, h*. In the middle of the box was placed the compass card, turning freely on a centre: motion was communicated to the card, shown also at *fig*. 3, by the bar magnet, *k l m*. Now this arrangement admitted of motion but in one direction; but in the form delineated at *fig*. 2 a double motion is produced, and, whatever be the direction of the supporting box, the compass needle must of necessity hang flat.

In the *azimuth* compass sights are added, shown at F, G, by which a star or any other distant body may be observed. The whole apparatus turns on the foot E, to which are attached the uprights C, D. B represents the ring which, by means of two screws, supports the central box. The compass card is shown at H. The azimuth compass will also answer for a steering compass.

MAGNETISM, ANIMAL. This fanciful science appears to have originated with Mesmer and other German illuminés, who believed that the power of a common magnet might be made to act on the human frame. They also believed that this power once imparted to a professor might afterwards be communicated to others without the agency of ferruginous bodies. So much of interest has lately been excited by the attempts to revive the long-exploded doctrines of animal magnetism that it may be advisable to present our readers with a brief outline of its history, and the phenomena said to be elicited. The principal means used to produce the effects of animal magnetism are such as touching and stroking with the hands, breathing on a person, fixing the eyes upon him, &c.; the magnetized person must always be of a weaker constitution, and, if possible, of a different sex, from the magnetizer; and it is indispensable that he should be of a disposition to believe without doubting. The phenomena themselves consist partly in bodily sensations (for instance, chilliness, heaviness, flying pains, oppressions, &c.), partly in a diminished activity of the external senses, partly in fainting, convulsions, sleep, with lively dreams, in which the magnetized person is transported to higher spheres, observes the internal organization of his own body, prophesies, gives medical prescriptions, receives inspired views of heaven, hell, purgatory, &c., reads sealed letters laid on his stomach, and, when awakened, is totally unconscious of what he has experienced. At the same time, the soul becomes so elevated and refined that the magnetized individual has an instinctive perception of the presence of the impure, and falls into fits at the approach of disbelievers in animal magnetism, and of all who investigate it by the rules of ordinary reason. Hence it is necessary to keep sceptics at a distance, when it is desired to witness the highest phenomena.

The magnetized person shows a remarkable connection with, and dependence on, the magnetizer, tasting what he eats, smelling what he holds before his nose, and no one else can bring him back from the magnetic state. In the sequel we shall give a brief exposition of the phenomena, as stated by Kluge, who appears, in his *Attempt at an Exhibition of Animal Magnetism*, to have given the fullest account of them. A scientific investigation of the influence which we are considering is hardly consistent with the views entertained of it by its adherents; for they maintain that mere reason cannot approach nor conceive this great mystery; it can be rightly apprehended only by a believer. The whole of the effects of animal magnetism seem to be ascribable to a heated imagination, to an excitement, half spiritual, half sensual, and to a morbid sensitiveness. The history of animal magnetism may be thus briefly detailed:—Anthony Mesmer, in 1772, attempted cures with the mineral magnet, and excited some sensation in Vienna, but at length declared that not the magnet, but a mysterious power in his own person caused the effects ascribed to the magnet, and that this power was related not only to the magnetic power, but to the attraction dispersed throughout the universe. But, a fraud which he attempted (the pretended restoration of sight to a girl) having been discovered, he proceeded, in 1778, to Paris. The great supporters of animal magnetism have recently been Kieser in Jena, and Wolfart in Berlin; the former explains the phenomena by the striking difference between life by day and life by night, both in the case of animals and vegetables; the latter adopts the mystical jargon of Mesmer. In 1820, the Prussian government caused a prize to be offered for the best treatise on this subject, but it was subsequently withdrawn.

MAGNETISM.

PLATE I.

Fig. 1.

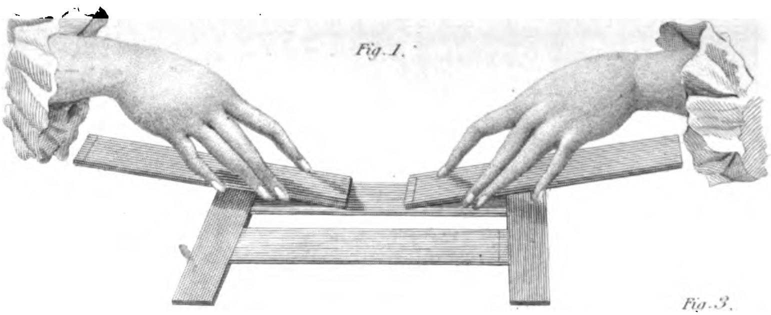


Fig. 2.

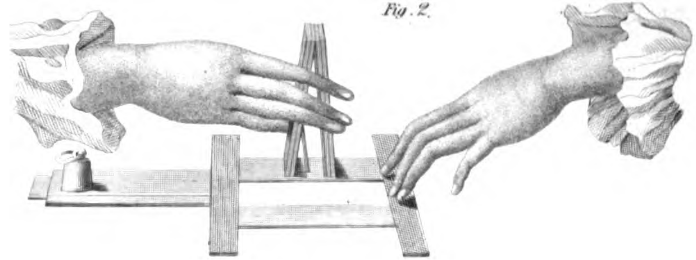


Fig. 3.

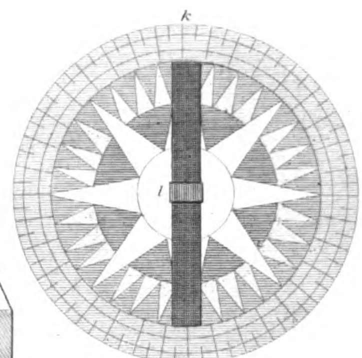


Fig. 4.

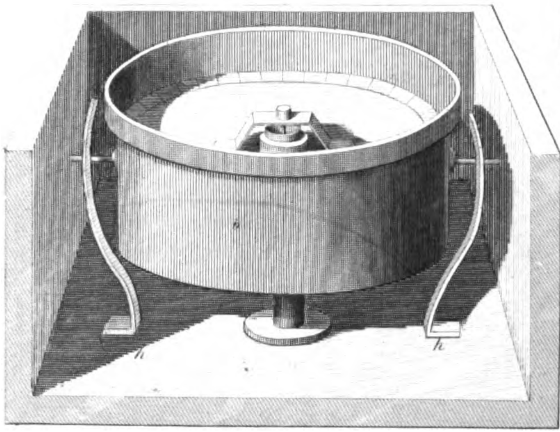
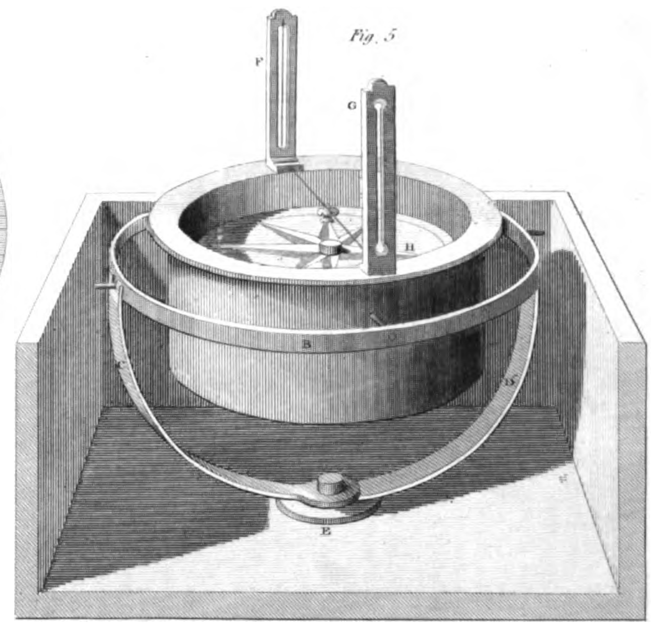


Fig. 5



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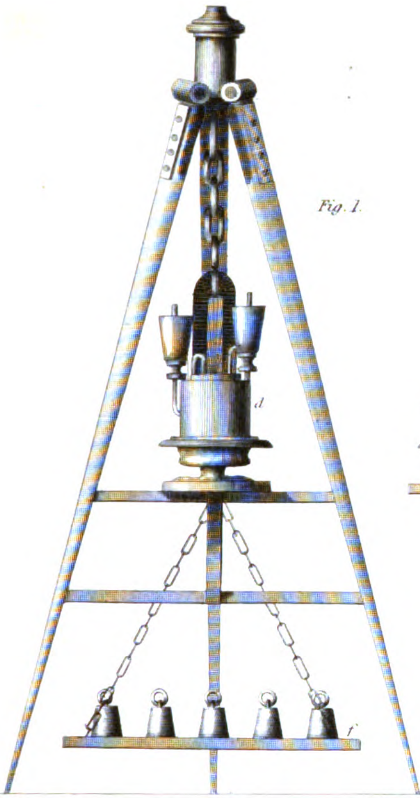


Fig. 1.

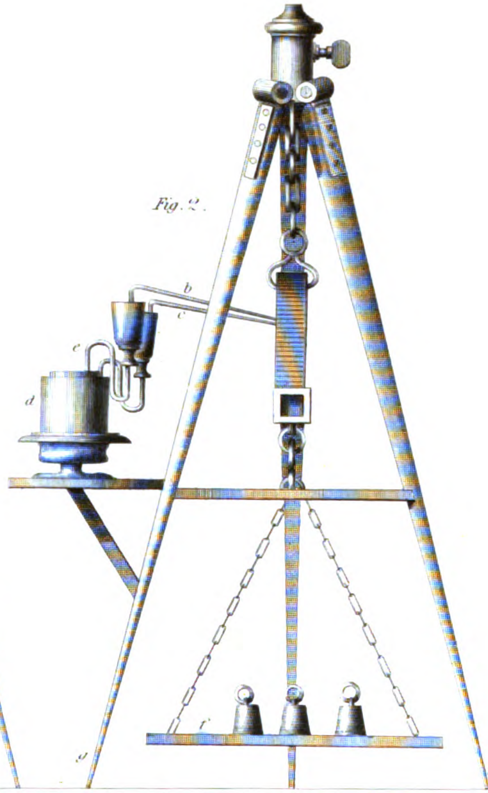


Fig. 2.

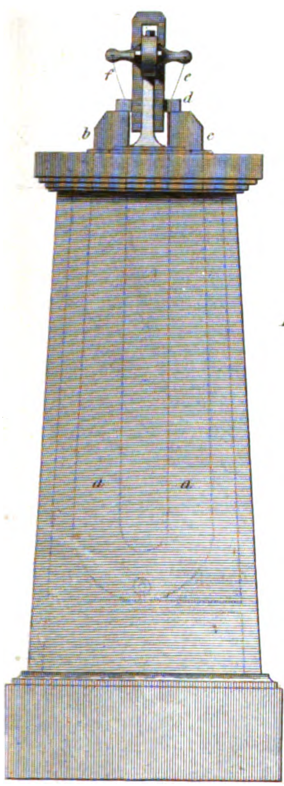


Fig. 3.

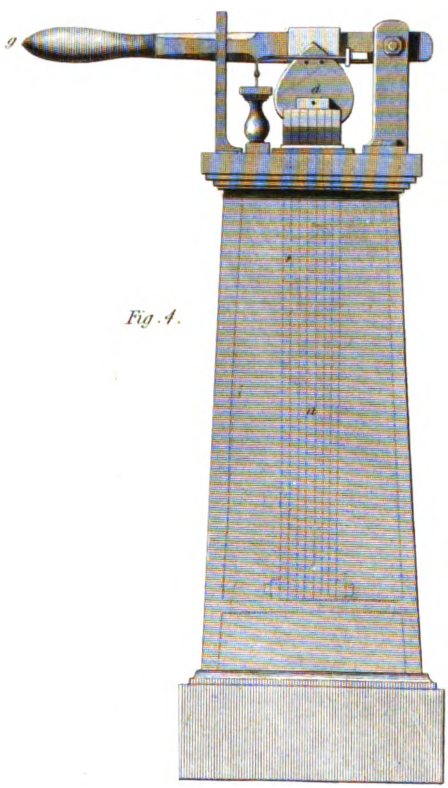


Fig. 4.

Drawn by Blunt

London Published by William Orr, Paternoster Row, Oct. 29, 1835.

We now proceed to an outline of the phenomena of animal magnetism, as described in Mr. Kluge's work. The phenomena, in the case of the magnetizer and the magnetized, are as follows:—

1. *The magnetizer.*—He is generally capable of producing a positive effect only so far as he possesses a higher degree of energy and vital power than the person magnetized. The man generally effects more than the woman. If the magnetizer is the weaker person, there either takes place no apparent effect, or the effects are inverted, viz. the positive effects are apparent in him, and the negative in the person magnetized. If the magnetizer undertakes the manipulation of a susceptible subject, he always feels a glow, and the sensation of a gentle flow from his palm, and particularly from the points of his fingers. If he covers his hands with silk gloves, or other electric bodies, he has not this latter feeling, and his operation is fruitless; but linen or leather gloves do not prevent the effect. After a successful operation, the magnetizer feels a general unpleasantness, a weakness in the digestive system, and, in general, a loss of power, in proportion to the susceptibility of the magnetized subject, and the duration or frequency of the operation. If the magnetizer, during the operation, is isolated with the magnetized subject by electrical bodies, his loss of power is less, but the effects which he produces are stronger.

2. *Phenomena in the person magnetized.*—The phenomena produced in the subject by a positive operation are of a double kind; either they have reference to the general state of the body, are then not periodical, but last during the whole cure, and therefore may be considered as the general effects of magnetism; or they have reference only to particular activities of the organization. Of the former sort are, 1. a general awakening and strengthening of the vital powers in all parts of the body, without considerable excitement, as well in the systems of the nerves and muscles, the vascular and digestive system, as the organs of secretion; 2. a mild excitement over the whole surface of the body, by which every irregularity and local reaction is neutralized and the equilibrium restored; 3. a withdrawing of the heightened vital power from the suffering organs to others; 4. a diminution or total suppression of the excitement producing the morbid activity of the nerves. The magnetizer not only should have a stronger body than the person magnetized, but also a perfectly healthy one. He must have attained the maturity of his bodily powers, but must still be within the age of active life; the mind, too, must be sound and strong, in order to master the affections and passions, to have a living faith and a firm will, and thus to attain perfect control over this means of cure, as also over the patient.

The phenomena of animal magnetism have been divided into six degrees. Those of the first degree are generally the following: first, the feeling of a strong current from the head to the extremities, after which a higher degree of heat follows, easily observable by the thermometer, greater redness of the skin, with increased perspiration, and a feeling of ease and comfort throughout the whole body. In the second degree, the warmth increases, and appears to the patient to diffuse itself from the stomach, as if from a central point, over the whole body. The pulse becomes generally fuller and stronger, and the breathing easier and deeper. The patient feels a heaviness in the eyelids and an irresistible desire to close them. If he does close them, they seem to him cemented by the strongest power, and, during the remainder of the magnetic effects, it is impossible for him to open them. All the other senses, however, remain active, and their activity is often heightened. The patient knows therefore every thing which is done about him, though he is not always capable of speaking. At the close of the magnetic operation, he opens his eyes by himself, or with the assistance of the magnetizer, and feels generally strengthened and well. After this, the patient observes, sometimes, a shining appearance before his eyes, similar to repeated lightning, a pricking in the points of the fingers and toes alternately, a heaviness and coldness in the extremities, unpleasant feelings about the region of the stomach, sickness, violent shuddering, wish to cough, &c.

The particular signs often accompanying the third degree are, especially, swoons, convulsive tremblings, real convulsions, cataleptic and even apoplectic fits. This state generally begins with all the signs of an approaching drowsiness. Repeated yawning, stretching, heaviness of the eyelids, announce it. A deep sigh generally follows, after which the eyes close entirely, and a state begins similar to sleep, in which the patient seems to be deprived of all sensation and consciousness. In the fourth degree, the patient awakens, not from his sleep, but within himself, and regains his consciousness; he knows himself again, yet in a changed relation to surrounding circumstances. The external senses are either closed entirely, or their character is changed, and only the internal sense remains the same. The *somnambulist* (as he is called in this state), entirely awakened within himself, distinguishes with his eyes nothing but light and darkness, and not always even these, although, as is sometimes the case, the eyelids are open. The ball of the eye is either drawn up convulsively or stiff, the pupil widened and without sensation. Next, the sense of feeling is metamorphosed into that of seeing, so that the somnambulist can distinguish by it, not only the outlines of things, but also colours, with perfect precision. The region of the stomach becomes the central point of all sensation, and it is chiefly through this region that the sense of sight is supplied. The somnambulist, therefore, can ascertain the time perfectly well by a watch, closely held to the pit of the stomach. By repeated exercise, the patient obtains this faculty in a higher degree, and what originally appeared to him indistinct becomes very clear. Persons appear to him more distinct than inanimate subjects.

Hearing is likewise performed in this state by the pit of the stomach, and the sense of smell becomes sometimes so acute as to distinguish the different ingredients of compound scents. Objects which the person does not regard in a healthy and natural state have often very sensible and even dangerous effects on him when in a state of somnambulism. The vicinity of a living being, whom the patient perceives at a distance of from ten to fifteen paces, is generally very disagreeable to him. If persons whom he dislikes touch him, paleness and coldness occur in the parts touched, and convulsions are generally the consequence. Among inanimate subjects, metals have the most unpleasant effect. To the magnet the somnambulist is still more sensitive than towards other metals. Of every thing which has occurred to the patient during this period, what he has perceived

thought, said, or done, he has, when awaking, either no recollection or a very faint one; but, if he is brought again into this state, he recollects every thing very well.

In the fifth degree, the patient attains, by his heightened consciousness and the increased strength of his general feelings, to that internal self-contemplation by which he is able to investigate even the minutest parts of his bodily structure. By virtue of this accurate knowledge of his internal frame, the *clairvoyant*, as he is called in this state, not only determines very distinctly the seat and quality of his disease, but at the same time an instinct developes itself in him which makes him understand the means necessary for his cure. Besides mentioning the remedies, the *clairvoyant* also indicates the kind of magnetizing necessary, and thus directs his own cure. This deep insight is not limited to the *clairvoyant* alone, but extends to persons brought into magnetic relations with him, whose sensations are always communicated to him. Between the magnetizer and the *clairvoyant* this sympathy is the strongest and most remarkable. Very often the feeling of disease in the magnetizer is not only communicated to the patient, but the disease itself, which in some cases has continued after the patient was awakened. Affections of the soul also pass from the magnetizer to the *clairvoyant*. Sometimes this sympathy reaches such a height that it remains even when the parties are distant from each other. This magnetic sympathy may be still more heightened, and then the *clairvoyant* has a clear insight into the internal physical state of persons in a magnetic connection with him, just as he has of his own; can determine their disease, its course and future phenomena, and prescribe the means of cure accordingly. He insists that he perceives the diseased state of others precisely as his own, by the stomach. His language becomes more elevated than ordinary, and is marked by fire, spirit, precision. His perception is livelier and stronger, his thinking freer and deeper, his judgment quicker and more penetrating. He not only perceives the present, and the influence of external relations, much more distinctly than before, but penetrates also into the most distant period of past time.

There is an obvious inclination of patients for each other, if they are treated by the same magnetizer, and particularly if they are in a state of somnambulism at the same time. The patient who has attained internal clearness by the fifth degree penetrates, in the sixth degree, the darkness of external things, and attains a higher view of the whole of nature. With uncommon clearness he often distinguishes the secrets of the past, what is distant and unknown in the present, and the events of coming time. If the patient is asked how he knows all this, he generally answers that it is as if he were told of it by some other person, or that he feels it through the pit of the stomach. He is always fully convinced of the truth of what he thus acquires. In respect to the choice of proper remedies, the *clairvoyant* is less limited than before. In the former degree, it was necessary to put him into connection with another person, by intermediate bodies; but, in this degree, he can be in this relation with any distant person, if he knows him, or feels a lively interest for him, or even if the magnetizer, or any other person brought into connection with the *clairvoyant* by actual touch, knows the distant person, and thinks intently of him. The view of the *clairvoyant* extends even into the future condition of others. He attains to a higher, fuller life than he had before. The body seems to be intimately amalgamated with the mind, to be blended into the most harmonious union with it. The individual is removed from every thing coarse and sensual, and placed in a state of serene and elevated self-contemplation. The feeling of the greatest bodily comfort and purity of soul produces a serene peace within him, which indicates itself by the noblest feelings. In this state, which, according to the *clairvoyants*, borders on heavenly felicity, they are incapable of impurity, and even the guilty fancy themselves virtuous.

Such are the wonders of animal magnetism, of which our readers may believe much or little. The attention which the subject has attracted in Europe is our excuse for the length of this article. The footing which it has gained, and the effects which it has produced, strikingly exemplify the power of imagination. It would require too much space to describe all the various manipulations and other operations by which the patient is placed in the magnetic state.

MAGNITUDE, APPARENT. If straight lines be drawn from the extremities of a visible object to the centre of the pupil of the eye, the angle formed by them is called the *visual angle*, or the *apparent magnitude* of the object. This angle varies with the different distances of objects, being larger when they are near and smaller when they are remote. Hence our idea of the magnitude of any object depends not only upon its true dimensions, but also upon the angle under which we view it; and objects of very different dimensions will appear of equal magnitudes if the visual angles under which they are seen are equal. Thus, for instance, the sun and moon, though their diameters are vastly different, each subtend an angle of about a degree. Besides, numerous prejudices and optical illusions, which we can never overcome, modify our ideas of the magnitude of objects. One of the most remarkable examples of such involuntary deception is that which every one has experienced in looking at the moon: when it has just risen, it appears larger than when it has reached the zenith. In the horizon, we are apt to imagine it at a greater distance from us than in the zenith, because in the former case there are intervening objects with which we can compare it, but in the latter no such objects occur. If the moon be viewed through a telescope, or an open tube, so as to exlude the intervening objects, it will appear of equal magnitude in both cases, and the whole illusion will immediately vanish.

MAHOGANY; the wood of the *swietenia mahogoni*, a lofty and beautiful South American tree. The wood is hard, compact, reddish-brown, and susceptible of a brilliant polish. It is one of the best and most ornamental woods known, forming very elegant articles of furniture. It is brought principally from Honduras and the West Indies, from which places it is exported, in vast quantities, to Great Britain, the continent of Europe, and especially to the United States of America, where it is so abundant and cheap as to have brought into disuse many of the native kinds of wood, which otherwise would be highly esteemed in cabinet-making. The tree is of rapid growth, and its trunk often has a diameter of four feet. Mahogany-cutting constitutes a principal occupation of the British settlers in Honduras. Gangs of Negroes, consisting of from ten to fifty each, are employed in this work: one of their number is styled

the *huntsman*, and his duty is to traverse the woods in search of the trees. When these have been discovered, a stage is erected against each, so high that the tree may be cut down at about twelve feet from the ground. After the branches are lopped, the task commences of conveying the logs to the water's side, which is often a work of considerable difficulty. They now float down the current singly, till they are stopped by cables which are purposely stretched across the river at some distance below. Here the different gangs select their own logs, and form them into separate rafts, preparatory to their final destination. Mahogany now begins to be rare in St. Domingo, Jamaica, and the other West India Islands. It is said to have been introduced into this country about the year 1724.

MAIDEN is the name of an instrument of capital punishment, formerly used at Halifax, in Yorkshire, and in Scotland, which is the prototype of the French guillotine. The maiden is a broad piece of iron a foot square, sharp on the lower part, and loaded above with lead. At the time of execution it was pulled up to the top of a frame ten feet high, with a groove on each side, for the maiden to slide in. The prisoner's neck being fastened to a bar underneath, on a sign given the maiden was let loose, and the head instantly severed from the body.

MAIL, COAT OF; also called *habergeon*. There are two sorts—*chain* and *plate mail.—Chain-mail* is formed by a number of iron rings, each ring having four others inserted into it, the whole exhibiting a kind of net-work, with circular meshes, every ring separately riveted. This kind of mail answers to that worn on the ancient breast-plates, whence they were denominated *loricæ hammatæ*, from the rings being hooked together. The habergeon, or hauberk, resembled a shirt in make, and was thrown over the upper part of the body above the clothing; a collar was applied round the neck; and there was a hood, or net helmet, to cover the head. Sometimes the crown consisted of plates of iron instead of rings, and iron plates in like manner were sometimes clasped around the breast and back. In addition to these parts, there were trowsers of similar construction, and it is probable that the feet were defended by a guard of the same description. A knight armed with a combination of chain and scale mail is shown in the engraving beneath.

Plate mail consisted of small *laminæ* or plates, usually of tempered iron, laid over each other like the scales of a fish, and sewed to a strong linen or leather jacket. The plates were in general very numerous, small, and united so as to move freely without impeding the motion of the wearer. The plate-mail was much more cumbrous than the chain-mail, a complete suit of ring-mail, still in existence, weighing thirty-nine pounds, while one of plate weighs between seventy and eighty, and in many cases much more. The hands were defended by gauntlets, sometimes of chain mail, but more frequently of small plates of iron riveted together, so as to yield to every motion of the hand. Some gauntlets enclosed the whole hand as in a box or case: others were divided into fingers, each finger consisting of eight or ten separate pieces, the inside being gloved with buff-leather: some of these reached no higher than the wrist, others to the elbow. The thighs of the cavalry were defended by small strips of iron plate laid horizontally over each other and riveted together, forming what were called *cuissarts* or thigh-pieces. Of these, some entirely enclosed the thighs; others only covered the front of them, the inside, next the horse, being unarmed. They were made flexible at the knees by joints, like those in the tail of a lobster. Tassets or shirts, hooked on to the front of the cuirass, were used by the infantry. For the defence of the legs, there were a sort of iron boots, called *greaves*. Plates of iron, covering the front of the leg, were also frequently worn over the stockings of mail. The greaves commonly covered the leg all round; with these they had broad-toed iron shoes, with joints at the ancle. Boots of jack-leather, called *curbouly (cuir bouillé)*, were also worn by horsemen. The different pieces of armour covering the body were called, collectively, a *coat of mail;* and a completely armed cavalier of the sixteenth century is shown in the engraving. Armour gradually continued decreasing, both from innovations and from its utility being diminished, till, in 1690, most of the defensive armour throughout Great Britain was returned to the Tower, whence it had been issued.

MAIN-MAST; the chief or middle mast of a ship. It is divided into four unequal sections, viz. the *main-mast*, properly so called, which rises from the deck; the *main-top-mast*, immediately rising from the main-mast; the *main-top-gallant-mast*, just above the main-top-mast; and the *main-royal-mast*, which crowns the whole. The form of the main-mast, like that of other masts, is taper. Each division of the mast has its particular sail, to which it gives name, as the *main-sail, main-top-sail*, &c.; and its particular yard, as the *main-yard, main-top-sail-yard, main-top-gallant-sail-yard*, &c.; besides its separate head or top, as the *main-top, main-top-mast-head*, &c. The ropes, tackling, &c., of each section are named in a similar manner.

MAJOR, in *military affairs;* the lowest of the staff-officers; a degree higher than captain. There appear

to have been officers called *majors* as early as 1560 in the German and Spanish troops; they were then the assistants of the colonels. At present, they are generally the commanders of battalions. The French, however, abolished this degree during the revolution; they have now *chefs de bataillon*. Their *gros major* is a half-invalid officer, who commands the depôt of the regiment.

MAJOR; an epithet applied to that of the two modern modes in which the third is four semitones above the tonic or key-note. Those intervals which contain the greatest number of semitones under the same denomination are also called *major*; as a third, consisting of four semitones, instead of three only, is termed a *major-third*; a sixth, containing nine semitones, instead of eight, is called a *major-sixth*.

MALLEABILITY; a property of metals, whereby they are capable of being extended under the hammer. (See DUCTILITY.)

MALLEUS, in *anatomy*; a bone of the ear, so called from its resemblance to a mallet, and in which is observed the head, the neck, and handle, which joins the membrane of the tympanum. (See EAR.)

MALMSEY WINE is a sweet wine, made from a grape originally brought from Monembasia, a small town on the south-east coast of the Morea. The English call the place by its Italian name, *Malvasia*, and the French, *Malvoisie*; hence the name of the wine, *Malmsey (vin de Malvoisie)*. Much of the Malmsey now used is made from a grape grown on rocky ground in Madeira, exposed to the full influence of the sun. It is left to hang about a month later than the grapes used for the dry wines, and is not gathered until partially withered.

MALT is the preparation of barley from which ale, beer, and porter, are brewed, all which are generally denominated *malt liquors*. For this purpose, the barley is steeped in water for three or four days. It is then taken out and suffered to lie until it begins to sprout or germinate. As soon as this process has advanced sufficiently, its further progress is prevented by drying it in a kiln, heated by coal or coke. The grain is now become mellow and sweet, and, after having been crushed in a kind of mill contrived for the purpose, its saccharine and mucilaginous portions are extracted by boiling water. The liquor thus produced has the name of *wort*, which, having undergone the process of fermentation, and having been flavoured by the addition of hops, &c., constitutes ale or beer. What remains of the malt after brewing is called the *grains*, which are used for feeding horses and cows. The tax upon malt constitutes a very important item in the revenue. The following document forms part of a parliamentary paper published last session (1832).

		From Barley at 20s. 8d. per Quarter.	From Bear, or Bigg, at 16s. per Qr	Total.	Duty.
Half Year ending Apr. 5, 1830.	England .	2,318,516	. . .	2,318,516	2,395,800
	Scotland .	258,848	55,614	314,463	311,968
	Ireland . .	201,587	. . .	201,587	208,306
Half Year ending Apr. 5, 1831.	England .	3,030,001	. . .	3,030,001	3,131,001
	Scotland .	251,874	60,326	312,200	308,531
	Ireland . .	157,670	17,516	175,186	176,938

MANCHINEEL; a West Indian tree, celebrated for the poisonous qualities of the milky juice which abounds in every part of it. When a drop of this juice is applied to the skin, it causes the same sensation as a burning coal, and quickly produces a vesicle. The Indians use it for poisoning the points of their arrows, which preserve their venom for a long time. The workmen employed in felling these trees first build a fire round the trunks, in order to make the juice evaporate, and cover their eyes with gauze; but, notwithstanding these precautions, they are subject to be incommoded by the dust. The accounts, however, which represent it as dangerous to sleep in the shade, or to come in contact with the rain which has fallen upon this tree, are highly exaggerated. The inhabitants of Martinique formerly burnt entire forests of the manchineel, in order to free their dwellings from its presence. It is said that drinking copiously of sea-water is the best remedy, when a portion of this fruit has been swallowed. It grows in the West Indies, and other parts of tropical America, in the immediate vicinity of the ocean.

MANDOLINE; an instrument, the name of which is much more musical than its tones. The Italian name is *mandola*. It has four strings, belongs to the lute and guitar species, and is played with a quill as well as with the finger. There are also instruments of this kind with six or more strings, which, therefore, approach nearer to the nature of the lute. It is chiefly in use in Italy, and is pleasing when it accompanies the easy song of the country people. The strings are of steel or brass.

MANEGE, or MANAGE, is used to denote the art of breaking and riding horses, or the place set apart for equestrian exercises. Most horses are, by nature, extremely docile, and, when proper means are used with them, they are very well disposed to obey their masters. These ought, therefore, to endeavour, from the commencement, to acquire the confidence of the animal by kind and gentle treatment, and by avoiding all unnecessary severity. Some horses, indeed, are naturally vicious or obstinate, and must be occasionally punished; but the chastisement should be inflicted with judgment and discrimination. Spirit has been sometimes mistaken for vice, and many horses, not naturally vicious, have been rendered so by severity and injudicious treatment.

A horse's education may commence between the ages of two and three years, and it will greatly facilitate future operations if he has been housed during the winter. About this age, a halter or cavesson (a noose-band) should be put upon the foal, that he may become familiar with it. The groom, too, when he cleans the animal, should lift each of his feet, and strike them gently with a piece of wood or a hammer, after which he will readily submit to be shod when necessary. Next, before feeding, the groom should put a saddle on the back of the foal, and remove it again with great caution. After a while, the girth may be bound over the saddle, and the foal left to stand and feed. Every thing should be taught gradually and gently, to avoid the danger of rendering the animal timid or vicious. The horse should now be made to run at the end of a long rein, held in the hand, a noose-band being put on his nose, and a man following him, if necessary, with a long whip. This exercise should be performed with great gentleness and but little at a time, that the horse may not be fatigued, stupified, or discouraged. After he has acquired a firm, regular, and determined motion, he may be mounted. Only a trench or snaffle and cavesson should be used at first. The bit and bridle should not be introduced till the horse has been taught to carry his head high, and is free in his motions. A fine carriage is to be given to the horse by

bringing his head in such a position as to form a perpendicular line from his forehead to his nose, after which his head should be brought a little more inwards by pulling the inward rein gently and by degrees, and crossing the outward rein a little over, whereby he acquires the most beautiful position, and is better able to go through his exercises.

The natural paces of a horse are a walk, a trot, and a gallop, to which some horses, of themselves, add an amble. In a walk, a horse lifts two legs on a side, one after the other, beginning with the hind leg first; in an amble, two legs on a side at the same time; in a trot, two at the same time and keeps two on the ground crosswise. In galloping straight forward, the horse may lead with either fore leg, but, unless the hind leg on the same side follows it, the legs are said to be disunited; in this pace all four legs are off the ground at the same time. In galloping in a circle, the innermost fore leg should lead, or he is said to gallop false. The canter or hand-gallop is not considered as a natural pace: it is an easier gallop, in which the hand presses on the bridle, to restrain the speed. When the horse has learned to go forward freely, he should be exercised for some time in the manner above pointed out, first at a walk, and then at a trot. The trot is to render him supple in the shoulders, and to make him go with a free, united, and determined action, for which no pace is so well adapted. A horse light in hand should be put to the extended trot. When he goes freely, he should be brought together by degrees, until he bends his legs, and goes unitedly and equally. If, when kept together, he slackens his pace, he should be pushed forward, though still kept gently in hand. If he be heavy in hand, he must be thrown back on his haunches, to shorten his steps and collect his strength. When he has been brought into a proper position, he should be made still more supple in the shoulders, by the lesson of the *épaule en dedans*, which is, perhaps, the most important lesson of any. For this purpose, the bend of the neck must be procured in the manner formerly described. When he has been ridden in this position till he goes with perfect steadiness and freedom, the rider should walk him forwards to the right, and endeavour, almost imperceptibly, to place him so that the hinder feet keep the straight line of a wall, while the fore feet come out about a foot and a half inwards, towards the centre. This must be effected by crossing the outward rein, in the right hand, towards the left, a little backwards, which compels the horse to bring the right shoulder forwards, and to cross the inward leg over the outward. The rider should also press his right leg to the horse's side, which brings in his shoulders. The same crossing should afterwards be effected in the hinder legs, by bringing in the fore legs, &c.

In every exercise, the rider should avoid all unsettled motion and wriggling with the legs. Every thing should be effected by the hands, and the legs should be used only in case of necessity. After the horse has been taught to go freely on this lesson to the right, the rider may change to the left. The horse should be ridden in the same manner across the course, and exercised alternately to the right and left, until he crosses his legs with perfect facility. He may then be taught to back. Whenever the rider stops, he should back a few paces, and then put the horse forwards by little at a time. In backing, if he attempts to rear, push him out immediately into a full trot.

Bits should not be used until the previous lessons have been well practised with the trench or snaffle. Horses should be taught to leap by degrees, beginning with small leaps. The rider must keep his body back, raise his hand a little, to help up the fore parts of the horse, and be very attentive to his balance, without raising himself in the saddle, or moving his arms. Horses should first leap standing, then walking, then trotting, then galloping. A low bar, covered with furze, is best to begin with, as it pricks the legs of the horse if he does not raise himself sufficiently, and prevents him from acquiring the dangerous habit of touching. In order to teach horses to stand fire, and to bear the sound of drums and other noises, they should be first accustomed to them in the stable at feeding time. All other things necessary to make a horse steady may be easily taught by good judgment, patience, and gentleness. Of all bad tempers and qualities in horses, those which are occasioned by ignorant riders and harsh treatment are the most common and the worst. For mounting, &c., see HORSEMANSHIP.

MANGANESE, in the condition of an ore, had been used in certain arts before its nature as a distinct metal was known. Scheele and Bergman, from an examination of this ore, inferred that it chiefly consisted of the oxide of a peculiar metal. To obtain the metal pure, the mineral is dissolved in muriatic acid, the oxide of iron precipitated by ammonia, and the solution evaporated to dryness; the residuum, after heating to expel the muriate of ammonia, is pure oxide of manganese, which is made into a paste, with a small quantity of oil and charcoal, and exposed, in a crucible, to the most intense heat of a powerful wind-furnace; the result of the process is the manganese in the metallic form. Hydrogen gas, passed over the heated oxide, will also reduce it. The metal is of a white colour, with a shade of gray, having a moderate lustre, which tarnishes, however, on exposure to the air. Its texture is granular; it is brittle and hard; specific gravity, eight; heated in oxygen or chlorine it takes fire, and forms an oxide or chloride.

The *protoxide* of manganese is best obtained by transmitting hydrogen gas over the deutoxide, peroxide, or carbonate of manganese, ignited by a spirit-lamp, in a glass tube. It is permanent in the air, but when heated to 600° Fahr. it absorbs oxygen very rapidly, and at a low red heat it passes from its green colour, almost instantaneously, into black. It consists of manganese 76.82, and oxygen 23.18. It is the basis of all the proper salts of manganese, which when pure are colourless.

The *deutoxide* is prepared by exposing the nitrate or peroxide of manganese, for a considerable time, to dull ignition. When heated with sulphuric acid, oxygen gas is extricated with effervescence, and a protosulphate results. The *peroxide* exists native and crystallized in perfect purity. It may be artificially prepared, by heating the dry proto-nitrate till a uniform black mass be formed, which must be pulverized, washed while hot with strong nitric acid, and again gently calcined with constant stirring. It contains twice as much oxygen as the protoxide.

The *red oxide* is formed by exposing the nitrate or peroxide of manganese to a white heat, out of the influence of smoky vapours. It has a brownish-red colour when cold, and is nearly black while warm. It consists of two proportionals of the protoxide and one of the peroxide. It dissolves in small quantities in dilute sulphuric acid, without disengagement of oxygen gas, forming an amethyst-red liquid. On heating this solution, or the red oxide, oxygen is evolved, the colour disappears, and a proto-sulphate remains. Strong muriatic acid dissolves the red oxide into a coloured solution, which exhales chlorine, and gradually passes into a colourless proto-muriate.

A compound, possessing very singular properties as respects the colours to which it gives rise when in solution, and which from this circumstance has received the fanciful name of the *mineral chameleon*, is formed by fusing together the native black oxide of manganese and potash, or its carbonate, which, on being dissolved in water, communicates to it a greenish-blue colour. The solution, on standing a little time exposed to the air, lets fall the oxide of iron which it contains, and the colour becomes blue; and, on the addition of warm water, or an acid, the solution assumes a violet colour, from which it soon passes to red, brown, black, and lastly becomes colourless. When the colour of the solution is bluish-green, the manganese is believed to be united with the alkali, in the condition of manganeseous acid; and when it is red the manganese is supposed to be in the state of manganesic acid. The manganeseous acid is, according to this view, very easy of decomposition. When combined with potash, it forms a submanganesite; and whenever the potash is saturated, or its action weakened, the manganeseous acid is decomposed into deutoxide of manganese and manganesic acid; hence the changes of the solution.

According to the experiments of Frommherz, the manganesic acid has a dark carmine-red colour, tastes sweetish at first, but afterwards bitter and astringent, and is destitute of smell. When heated with care, it volatilizes. It is decomposed by a current of hydrogen gas, the hydrogen acids, carburet of sulphur, the metals, and all organic substances. The salts of manganese are usually prepared from the black peroxide. The acids, which have a strong affinity to the protoxide, expel the excess of oxygen, especially if their action is aided by heat; with other acids, it is necessary to add a little carbonaceous matter, as sugar, to abstract a portion of oxygen from the peroxide. The principal salt is the *sulphate* of manganese, which may be thus prepared: the acid acts very slowly on the metal itself; if diluted, however, it acts more quickly, hydrogen gas being disengaged, of a fetid smell. The solution, when concentrated, is of a rose colour; when obtained neutral, it affords, on evaporation, granular crystals of a reddish colour, transparent and soluble. Its taste is styptic and bitter, and it is very soluble in hot water.

Nitrate of manganese may be formed from the carbonate. It is very soluble, and difficult to crystallize. It may also be formed by making the acid act on a mixture of peroxide of manganese and sugar or gum, the vegetable substance serving to reduce the manganese to the minimum of oxidizement, while much carbonic acid is evolved. The muriatic acid is equally incapable of combining directly with the black oxide, but, according to the usual law, it de-oxidates it: one part of the muriatic acid is decomposed; its hydrogen combines with the excess of oxygen of the black oxide to form water; the chlorine, the other element of this portion of the acid, is evolved; and the rest of the muriatic acid unites with the protoxide of manganese to form the *muriate*. The solution of muriate of manganese is of a rose colour when concentrated, and affords, by evaporation, small crystals of a pale rose colour, which are four-sided tables; they are deliquescent, very soluble in water, and, by a red-heat, are converted into a red chloride.

Carbonate and *phosphate* of manganese may be formed by double decomposition, being thrown down in the state of insoluble precipitates. The salts of manganese suffer decomposition from the alkalies, which precipitate the oxide: they are not decomposed, however, by the inflammables, or the other metals, which is a proof of the affinity of manganese to oxygen. Oxide of manganese combines with those earths which are capable of vitrification and with their compounds, and communicates to the glasses which they form a violet tinge; it imparts the same colour, also, to borax and other vitrifiable salts. When heated with these fluxes, by the blow-pipe, the colour soon disappears in the interior flame from de-oxidation, but appears again if a little nitre is added.

Sulphuret of manganese was obtained by Berthier by heating the sulphate in a charcoal crucible; it was of a gray colour and crystalline appearance. Manganese, from its infusibility, does not combine readily with many of the metals. It shows, however, considerable affinity to iron, occurring frequently combined with it in nature. It is contained, also, in those ores of iron which are best adapted to the fabrication of steel, and is supposed to improve the quality of steel. Gold and iron are rendered more fusible by a due addition of manganese; and the latter metal is rendered more ductile. Copper becomes less fusible, and is rendered whiter, but of a colour subject to tarnish. Manganese is applied to no use in its metallic form. The black oxide is employed by the chemist in preparing oxygen and chlorine gases. It has long been used in the art of glass-making, to counteract the green tinge communicated by the iron contained in the materials—an effect which it produces by yielding oxygen to the oxide of iron, and bringing it to a high degree of oxidation; in a larger quantity added to glass, it gives a purple colour. It is also used to give a black colour to earthen-ware.

MANGEL-WURZEL; a kind of beet, which does not afford fodder of as good quality nor in such abundance as was supposed at the time of its introduction; but it is valuable from its size and hardy nature. The leaves may be eaten as a substitute for spinach, and continue in season long after that plant has withered. In some parts of Germany, the farmers prefer it for their cattle to most vegetables: and, besides, it can be obtained at the latter part of the season, when green fodder is much wanted.

MANIFEST is a regular list of a ship's cargo, containing the mark and number of each separate package, the names of the persons by whom the different parcels of goods are shipped, and those of the persons to whom they are consigned, a specification of the quality of the goods contained in each package, as rum, sugar, tea, coffee, &c., and also an account of the freight that the captain is to receive from the consignee of such goods, on his arrival, correspond-

ing with the bills of lading which he has already signed. The manifest is usually signed by the ship-broker who clears the vessel out at the custom-house, and by the captain, and serves as a voucher for the latter, whereby to settle his account with his owners, &c.

MANIOC; a shrub allied to the castor plant, and interesting from its nutritious properties. This plant is easily cultivated, grows rapidly, and produces abundantly. It is much less subject to injury from the ravages of animals, or variations of the atmosphere, than most crops, and, besides, accommodates itself to almost every kind of soil. The roots require at least a year to bring them to perfection; neither can they be kept in the ground for a longer period than two years. The cultivated varieties are very numerous. It is said that an acre of manioc will nourish more persons than six acres of wheat. Every part of the plant is filled with the milky juice, which is a very violent and dangerous poison, bringing on death in a few minutes when swallowed; and it may well excite surprise that human ingenuity should have converted the roots into an article of food. For this purpose the roots were formerly rasped with rough pieces of stone; but they are now ground in wooden mills, and the paste is put into sacks, which are exposed for several hours to the action of a very heavy press. By this means it is deprived of all the poisonous juice, and the residue is called *cassava*. Cassava flour, when kept free from moisture, continues good for fifteen or twenty years. It is very nutritious, half a pound a day being sufficient for any one. The Creole women prefer the cassava to wheaten bread, but, to a European, the taste is rather insipid. It is also the basis of several different beverages, some of which are acid, agreeable, and even nutritive. The substance called *tapioca*, which is frequently imported into this country, and is used for jelly, puddings, and other culinary purposes, is separated from the fibrous part of the roots by taking a small quantity of the pulp, after the juice is extracted, and working it by hand till a thick white cream appears on the surface. This being scraped off and washed in water gradually subsides to the bottom. After the water is poured off the remaining moisture is dissipated by a slow fire, and the substance, being constantly stirred, gradually forms into grains about as large as those of sago. This is the purest and most wholesome part of the manioc.

MANIPULATION; work done with the hands. The word is used in pharmacy for the preparation of drugs; and in chemistry for the preparation of substances for experiments.

MANNA. This substance, which is so frequently employed in the *materia medica*, and which forms a considerable article of commerce, exudes naturally or from incisions made in the trunk and branches of a species of ash *(ornus rotundifolia)*. It first appears as a whitish juice, thickens on being exposed to the air, and, when dried, forms a whitish or reddish granular substance, which is the manna of commerce. The tree is a native of Italy, and is cultivated extensively in Sicily. June and July are the two months in which the manna is collected. It is detached from the trees with wooden knives, and is afterwards exposed to the sun for drying. A little rain, or even a thick fog, will often occasion the loss of the collections of a whole day. The taste of manna is sweet, and slightly nauseous. It is a mild purgative, and is principally administered to children. The *fraxinus virgata* also yields manna, but it cannot be obtained from any other species of *ornus*.

MANNER, *in the fine arts*, is used in two different meanings:—First, it signifies the habitual style of an artist or a school of artists. Secondly, *manner* (also *mannerism)* is used as a term of reproach, and designates those qualities of a work of art which do not proceed naturally from the subject treated, but from the individual character of the artist, or the false taste of an age. Such are the studied yet untrue performances of certain actors, the phraseology or conceptions of certain poets, the colouring or composition of certain painters, &c.

MANŒUVRE, in the *military art;* a movement given to a body of troops, according to the rules of tactics, by which it is intended to gain a decisive advantage over an enemy, or to regain advantages which the enemy has already won. A manœuvre may be executed by large or small masses, according to a preconcerted plan, or upon the sudden impulse of genius seizing upon a favourable moment: in general, it may be said that manœuvres have become more practicable in proportion as armies have grown larger, and discipline stricter. In an ancient battle, after the combat was well commenced, the commander lost, in a great degree, the direction of his troops: in modern battles he is enabled by manœuvres to exert a much more controlling influence, though there are still moments when he is obliged to let the battle rage. To execute effective manœuvres in the heat of battle requires great coolness and clear-sightedness in the commander, and thorough training in the troops. A manœuvre generally is a test of the excellence of the officers of all degrees.

One of the most important manœuvres is that of outflanking an enemy, in which the general keeps back part of his line, whilst the other part strives to turn the wing of the enemy, or to attack it with the assistance of a division particularly appointed to get round it, and thus to throw the enemy into confusion. The invention of this manœuvre is ascribed to Epaminondas; he owed to it his victories at Leuctra and Mantinea. Philip, Alexander, Cæsar at Pharsalia, Baner at Wittstock, Torstenson at Jankowitz, Frederic the Great at Hohenfriedberg and Leuthen, Napoleon, and other generals, owe their most brilliant successes to this manœuvre. In executing it, the attacking army always receives an oblique direction, and the attack is sometimes made *en échelon*, as at Leuthen. The breaking through the enemy's line—a chief manœuvre in naval warfare—is, in land-battles, one of the boldest and most dangerous. The retreat *en échequier* (chess-board) is one of the most advantageous and most fitted to preserve calmness and order among the troops. The change of front during the combat is very dangerous, and rarely succeeds. The issue of a battle, where the other circumstances are nearly equal, depends upon the capacity of the troops for manœuvring; hence manœuvring in peace with large bodies is very necessary, in which the chief movements of both parties must be laid down beforehand; but the details ought to be left to the moment, so that the judgment of the officers shall be exercised.

In the provinces of Prussia large bodies of troops are annually assembled for the purpose of manœuvring. In 1823, from September 5 to September 20, 40,000 troops were collected for this object near Ber-

lin. Gustavus Adolphus and Charles XII. exercised their troops so well that they were allowed to be the best in Europe; but Frederic the Great conceived the whole art of war from a new point of view; and from Potsdam, where he superintended the reviews and manœuvres of his guards, and the garrison of Berlin, may be said to have proceeded the new art of war. There he perfected the movements which were afterwards introduced into the army at large; and generals from all Europe were sent to study his manœuvres. But, as so often happens with the creations of genius, the application of his plans by inferior men was attended with a pedantic minuteness of detail with which the armies of Europe were embarrassed when the wars of the French revolution took place. The genius of the French generals now reformed the art of war anew; manœuvring on a great scale was invented by them. Napoleon developed it still further, and the rest of Europe learned it from him.

MANOMETER; an instrument to measure or show the alterations in the rarity or density of the air.

MANTELETS, in the *art of war;* a kind of movable parapets, made of planks about three inches thick, nailed one over another, to the height of almost six feet, generally cased with tin, and set upon wheels, so that in a siege they may be driven before the pioneers, and serve as blinds to shelter them from the enemy's small shot.

MANUFACTURES. Great Britain is essentially a trading country. Napoleon called us a "nation of shopkeepers," but he might more truly have characterised us as a nation of manufacturers. And yet, in the strict sense of the word, we had no claim to the title prior to the commencement of the last century. Our principal manufactures date their origin from the invention of the steam-engine; and it is most likely that we should have now been receiving the manufactures of other nations, instead of supplying *our own,* if this stupendous machine had never been improved by Mr. Watt. One of the principal reasons why so many more improvements are made in this country beyond what is found in the manufactures of any other arises from the circumstance that in Great Britain the masters have generally been workmen, whilst, among our continental rivals, they are almost invariably the possessors of the soil and the princes of the land. There are few manufactures on any very extended scale found either in the metropolis or its environs. It is only in the provincial districts that we observe the great principle of a "division of labour," by which prices are reduced, fully developed. Under these various divisions then our readers will best see the progress of the manufactures of Great Britain illustrated, and in our article COMMERCE will be found the results of that division of labour on a large scale, as it affects the commerce of the world.

MANURES; vegetable, animal, and mineral matters, introduced into the soil, to accelerate vegetation and increase the production of crops. If the soil to be improved be too stiff from excess of clay, it will require sand; if too loose from excess of sand, it will be benefited by clay; but, when sand is mixed with argillaceous soil, the latter must be broken and pulverized, which may be effected by exposing it to the frost, and afterwards drying it. *Marl* is a natural compound earth, used with great success in the amelioration of soils. It consists of a mixture of clay and lime, sometimes containing a little silica and bitumen. Those varieties of it which contain more clay than lime are advantageous for a dry sandy soil; while calcareous marl, or that in which the lime predominates, is suited to an argillaceous soil. The great advantage of marl is, that it dilates, cracks, and is reduced to powder, by exposure to moisture and air. Marl in masses would be totally useless in the ground; and it is necessary to begin by laying it on the ground in heaps; for the more it is heaped the more it dilates, splits, and crumbles to dust, in which state it is fit to spread upon the ground. Marl is sometimes formed into a compost with common manure, before it is laid on the soil; in this state, however, it should be applied sparingly at a time, and renewed frequently. It operates by subdividing the soil, and hastening decomposition, its calcareous particles disorganizing all animal or vegetable bodies, by resolving them into their simple elements, in which state they combine with oxygen, and facilitate this union. The best time for marling is the autumn.

Quick-lime, and especially that derived from fossil or living shells, is another excellent means of amending soils. It is particularly adapted to cold marshy soils, abounding in organic matters, as it assists powerfully in the conversion of animal and vegetable substances into nourishment for plants. *Ashes* are very beneficial to the soil, by attracting moisture from the atmosphere, in consequence of the alkali they contain, and thus accelerating vegetation. *Gypsum* is, however, the most universal mineral manure; but chemists are not agreed as to the manner in which it acts on vegetation. It is strewed, in the state of fine powder, over crops, when the leaves are in full vigour, towards the latter end of April or the beginning of May.

Common manure is composed of the remains of organized bodies, of every description, whether animal or vegetable, in a state of decomposition. The principal result of this decomposition is carbonic acid, which, becoming dissolved in water, finds its entrance into the plant by the pores in the fibres of the roots, and, being every where distributed through the vegetable tissue, deposits its carbon for the growth of the plant, while its oxygen escapes into the atmosphere, through the pores of the leaves. Manure which has not completely undergone the process of fermentation, so that the straw is not yet wholly decomposed, is best adapted to strong compact soils: the tubular remnants of straw answer the purpose of so many little props to support the earth, and afford a passage for the air, thus rendering the soil lighter; besides, the completion of the fermentation taking place after the manure is buried in the soil has the advantage of raising the temperature. Those bodies which are subject to the most rapid decomposition are most employed for manure. Of this description are animal manures in general, which require no chemical preparations to fit them for the soil. The great object of the farmer is to blend them with the earthy constituents, in a proper state of division, and to prevent their too rapid fermentation.

In maritime districts, *fish,* when sufficiently abundant, are sometimes used to manure the land. They afford a powerful manure, and cannot be ploughed in too fresh, though the quantity should be limited. Mr. Young records an experiment, in which herrings, spread over a field, and ploughed in for wheat, produced so rank a crop that it was entirely laid before harvest. Amongst excrementitious solid substances,

one of the most powerful is the *dung of birds* that feed on animal food, particularly the dung of sea-birds. The *guano*, which is used to a great extent in South America, and which is the manure that fertilizes the sterile plains of Peru, is a production of this kind. It contains a fourth of its weight of uric acid, partly saturated with ammonia, and partly with potash; some phosphoric acid, combined with the bases, and likewise with lime; small quantities of sulphate and muriate of potash; a little fatty matter; and some quartzose sand.

Night-soil, it is well known, is a very powerful manure, and very liable to decompose. Its disagreeable smell may be destroyed by mixing with quicklime, after which, if exposed to the atmosphere in layers, in fine weather, it speedily dries, is easily pulverized, and, in this state, may be used in the same manner as rape-cake, and delivered into the furrow with the seed. The Chinese, who have more practical knowledge of the use and application of manure than any other people existing, mix their night-soil with one-third of its weight of fat marl, make it into cakes, and dry it by exposure to the sun. In this state it is free from any disagreeable smell, and forms a common article of commerce of the empire. After night-soil, *pigeons' dung* comes next in order as to fertilizing power. If the pure *dung of cattle* is to be used as manure, like the other species of dung which have been mentioned, there seems no reason why it should be made to ferment, except in the soil; or, if suffered to ferment, it should be only in a very slight degree. A slight incipient fermentation is undoubtedly of use in the dunghills; for by that means a disposition is brought on in the woody fibre to decay and dissolve, when it is carried to the land, or ploughed into the soil; and woody fibre is always in great excess in the refuse of a farm. Too great a degree of fermentation is, however, very prejudicial; and it is better that there should be no fermentation at all before the manure is used than that it should be carried too far. In cases where farm-yard dung cannot be immediately applied to crops, the destructive fermentation of it should be prevented very carefully, by defending the surface of it, as much as possible, from the oxygen of the atmosphere: a compact marl, or a tenacious clay, offers the best protection against the air; but before the dung is covered over, or as it were sealed up, it should be dried as much as possible. If the dung be found to heat at any time, it should be turned over, and cooled by exposure to air. When a thermometer, plunged into it, does not rise above 100° Fahr., there is little danger of much aëriform matter flying off; if the temperature be above that point, the dung will require to be immediately spread open. Also, when a piece of paper, moistened in muriatic acid, held over the steams arising from a dung-hill, gives dense white fumes, it is a certain test that the decomposition is going too far; for this indicates that volatile alkali is disengaged. The situation in which dung is kept by farmers is often injudicious, it frequently being exposed to the direct influence of the sun; whereas it should always be kept under sheds, or at least on the north side of a wall. Less perishable substances, of animal origin, are sometimes used as manure, such as *horns*, *hair*, *feathers*, and *bones*; but, owing to their dry nature, they require a longer period for their decomposition. They are not calculated for annual harvests, but to fructify the soil for a produce of much longer duration, such as that of olive-trees, and of vineyards.

Vegetable manure does not undergo fermentation previous to being buried in the soil. Of this kind of manure, *green crops*, such as clover, lupins, and buckwheat, which are ploughed into the soil, are the best, since they contain a considerable quantity of water, and, when buried, serve to lighten the soil previous to decomposition. It is especially adapted to hot climates. *Rape-cake*, which is used with great success as a manure, contains a large quantity of mucilage, some albuminous matter, and a small quantity of oil. It should be used recent, and kept as dry as possible before it is applied. It forms an excellent dressing for turnip crops, and is most economically applied by being thrown into the soil at the same time as the seed. *Sea-weeds*, consisting of different species of *fuci*, *algæ*, and *frevæ*, are much used as a manure. This manure is more transient in its effects, and does not last for more than a single crop, which is easily accounted for from the large quantities of water, or the elements of water, which it contains. It decays without producing heat when exposed to the atmosphere, and seems, as it were, to melt down and dissolve away. *Soot*, which is principally formed from the combustion of wood and pit-coal, contains, likewise, substances derived from animal matters, and is a very powerful manure. It requires no preparation, but is thrown into the ground with the seed.

The foregoing species of manure have, for the sake of convenience, been described separately, though they are very rarely employed unmixed by the farmer; on the contrary, the most common manure consists of a mixture of animal, vegetable, and mineral substances, such as farm-yard litter, night-soil, mud from the streets, dust from the roads, or earth from the bottom of ponds and rivers, abounding with organic remains of fish, shells, and rotten plants. Before being laid upon land, it usually requires to be well turned up and exposed to the air for some time; but, as soon as it is spread, it should be ploughed in, to prevent loss by evaporation. As to the depth below the surface of the ground to which it should be deposited, it may be remarked that this should never be below the reach of the roots of the plants it is intended to nourish; for, in proportion as it is dissolved and liquefied, it will naturally descend. And it is better to manure lands in the spring than in autumn, lest the winter rains should dissolve it too much, and endanger its sinking below the roots of the crop. With regard to the quantity of manure, it is a commodity so scarce that it is not likely to be employed in excess. This occurs, however, sometimes in garden culture, and it produces a strong and disagreeable flavour in the vegetables. But the stock of manure is generally so limited that it has hitherto been the study of agriculturists rather to discover some means of compensation for a deficiency than to avoid danger from excess.

We cannot close this account of the best modes of applying manure without briefly adverting to the economical arrangements which have lately been made for effecting this object in Holland. It forms the principal feature in a system of rural economy, by means of which establishments called "pauper colonies" are enabled to support themselves, and yet return an annual interest to those who have established them. Mr Jacob furnishes the following facts:—

"When the house and barn are built, the soil formed, by mixing sand and clay to a consistence which makes it sufficiently retentive of moisture, the land manured, dug, and one crop sowed or planted on it, then a family consisting of from six to eight persons is fixed on it, at an expense of about 141*l*. To enable this household to subsist or pay the rent, and to save something, it is necessary that very intense manuring be persevered in. The directors therefore require, and by their enforcement of the prescribed regulations, indeed, compel each family to provide sufficient manure to dress the *whole* of the land every year. For this purpose each household must provide itself with three hundred fodder of manure, yearly; or, in English terms, one hundred and fifty tons, or at the rate of more than twenty tons to each acre. When it is considered that few of our best English farmers can apply one half that quantity of manure, it will not appear wonderful that seven acres should be made to provide for the sustenance of the same number of persons, and leave a surplus to pay rent and to form a reserve of savings. On each farm the live stock of two cows, or one cow and ten sheep, to which may be added pigs, would not nearly enable the cultivator to manure his small portion of land once even in four or five years.

"It hence becomes necessary to form masses of compost, the collecting the materials for which forms the greater part of the employment of the colonists. These masses are created almost wholly by manual labour, of that kind which, but for such an application of it, would be wholly lost to the community. As straw is at best, in the early period, not abundant, and as that from the corn must at first be chiefly used as food for the cattle or for covering to the houses, other materials, which the heaths furnish, are resorted to in order to make beds for the cattle. The heath land is pared, but the operation is to cut with the spade a very thin slice of the earth, and not to the bottom of the roots of the plants, that they may, as they soon will do, shoot again; the parings are not only made thin, but in narrow strips or small spots. Thus but little soil is taken away, and the roots, though cut, are not all of them destroyed; the parts that are left bare are protected from being too much dried up by the sun and wind, and the seed of the ripe heather is scattered over the spaces left bare near them, and soon bring forth the same plants. By this operation there is a constant succession provided of heathy material.

"This paring for the heath is a joint operation, performed by the men in a kind of military lines. The society pays each for the work he performs, and, when the average cost is ascertained, the sods are sold to the several households at the same price, and are carried to their respective farms in small one-horse carts, which are kept by the society for that and for similar purposes, to which mere manual labour cannot be so beneficially applied. When these sods are dried and conveyed to the barns of the colonists, they are piled in a kind of stack, and portions of it are pulled out, not cut out, to ensure their being broken into small fragments. With these the bedding of the cows or sheep, as the case may be, is formed.

"The use of bog turf or peat as one of the materials of compost is not approved. It impedes the process of fermentation, which is the most important part of the preparation of the heaps of manure. Another expedient is therefore adopted, by paring the second year's grass land, whether of clover, rye grass, or fiorin. These clods, containing a proportion of the roots of the plants which have been before harvested from them, and much garden mould, become useful auxiliaries to the heathy turf, and spare the use of that material, which if solely applied would require almost as much land to supply it as the farm itself.

"The bedding of the cattle with fresh material is performed every morning and evening, and remains under them seven days and nights, when it is wheeled to the dunghill. Each morning that which lies near the hinder part of the cow is thrown forward, and the part towards its head takes its place, and fresh heather, about a quarter of a fodder, or two hundred and fifty pounds, added to the bedding; the same is also done every evening. The sheep and pigs are only supplied with fresh heather once a day. It is reckoned that ten sheep make an equal quantity of dung with one cow. It must be obvious to every one that the changing and consequent turning over thirteen times must make the mixture of the animal and vegetable substances more equably rich; and the uniform treading of it must break it into small particles and give greater scope to the fermentative putrefaction.

"Each week the stalls are cleaned, and the dung conveyed to the place appointed at the back of the barn. This is of a round shape, from three to four feet in depth. The bottom and sides are walled with either clinkers or turf, and made water-tight. It is commonly from twelve to fourteen feet in diameter, and sufficiently capacious to contain the dung made by the cattle in the course of four weeks. The mass is thus composed of portions which have remained from four weeks to one day, over which the ashes from the household and all the sweepings of the premises are strewed. Adjoining to the dung-heap is the reservoir, into which the drainings of the stalls are conveyed. Equal care is taken that every other material for compost is preserved. In England, little attention is paid to these matters; and even in agricultural districts many of the most valuable ingredients for fertilizing the earth (soap-suds, for instance) are constantly thrown away. This cesspool, containing about a hogshead, is never allowed to run over; and, if it has not rained, is every other day filled up with water, and then with a scoop taken up and sprinkled over the heap of dung. As this heap contains four week's dung, or thirty fodder, or fifteen tons, the administering fourteen such portions of rich fermenting matter must vastly enhance the value of the whole for the purposes of vegetation." (See *Rotation of crops*.)

Map. See this word in Geographical Division.

Maple; a well-known American tree. It grows in moist situations, from lat. 49° to the gulf of Mexico, both in the Atlantic and western States. The bright red blossoms appearing at a time when there is no vestige of a leaf in the forest render this tree very conspicuous at the opening of spring; and again at the close of the season it is not less conspicuous, from the scarlet colour which the leaves assume when they have been touched by the frost. The leaves are cordate at base, unequally toothed, five-lobed, and glaucous beneath. It attains the height of seventy feet, with a diameter of three or four at the base. The wood is easily turned, and when polished acquires a silken lustre; it is hard and fine-grained,

and is employed chiefly for the lower parts of Windsor chairs, sometimes for saddle trees, wooden dishes, and similar purposes. The variety called *curled maple*, from the accidental undulation of the fibres, is one of the most ornamental woods known, and bedsteads made of it exceed in richness and lustre the finest mahogany. It is sometimes employed for inlaying, but its most constant use is for the stocks of rifles and fowling pieces. The sugar maple is one of the most valuable trees. Besides the sugar which is obtained from the sap, the wood affords excellent fuel, and from the ashes are procured four-fifths of the potash which forms such an important item in American exports. The sugar is superior in quality to the common brown sugar of the West Indies, and, when refined, equals the finest in beauty. It is, however, little used. The potash is exported from the two principal northern ports, New York and Boston. To the latter place the wood is brought in great quantities from Maine for fuel, and is esteemed hardly inferior to hickory. In Maine and New Hampshire, it is employed in ship-building for the keel, and likewise in the lower frame; for the axle-trees and spokes of wheels; and sometimes in the country for the frames of houses. A variety, with undulations, like the curled maple, and containing besides small spots, is called *bird's eye maple*, and forms exceedingly beautiful articles of furniture.

MARBLE, in common language, is the name applied to all sorts of polished stones employed in the decoration of monuments and public edifices, or in the construction of private houses; but, among the materials thus made use of, it is necessary to distinguish the true marbles from those stones which have no just title to such a designation. In giving a short but universal character of marble, it may be said that it effervesces with dilute acid, and is capable of being scratched with fluor, while it easily marks gypsum. These properties will separate it at once from the granites, porphyries, and silicious pudding-stones, with which it has been confounded on one side, and from the gypseous alabaster on the other. From the hard rocks having been formerly included under the marbles, comes the adage, "hard as marble."

Marbles have been treated of under various divisions by different writers. The most frequent division has been that of two great sections—*primitive* marbles, which have a brilliant or shining fracture, and *secondary* marbles, or those which are possessed of a dull fracture. This classification has grown out of the idea that the former class was more anciently created —an opinion which the deductions of geology for the most part sufficiently confirm, though occasionally we find a marble of a compact and close texture in old rocks, and, on the other hand, those which are highly crystalline in very recent formations. Daubenton has founded a classification of marbles upon the colours which they present; those of a uniform colour forming one class; those with two colours, another; those with three shades, a third; and so on. The best classification of these substances, however, is that of M. Brard, which divides all marbles into seven varieties or classes:—viz. 1. *marbles of a uniform colour*, comprehending solely those which are either white or black; 2. *variegated marbles*, or those in which the spots and veins are interlaced and disposed without regularity: occasionally, this variety embraces traces of organic remains; when these are disposed in star-like masses they are sometimes called *madrepore marbles*; 3. *shell marbles*, or those which are in part made up of shells; 4. *lumachelli marbles*, or those which are apparently wholly formed of shells; 5. *cipolin marbles*, or those which are veined with green talc; 6. *breccia marbles*, or those which are formed of angular fragments of different marbles, united by a cement of some different colour; 7. *pudding-stone marbles*, or those which are formed of reunited fragments, like the breccia marbles, only with the difference of having the pebbles rounded in place of being angular.

Parian marble; its colour is snow-white, inclining to yellowish-white; it is fine, granular, and, when polished, has somewhat of a waxy appearance. It hardens by exposure to the air, which enables it to resist decomposition for ages. Dipœnus, Scyllis, Malas, and Micciades, employed this marble, and were imitated by their successors. It receives, with accuracy, the most delicate touches of the chisel, and retains for ages, with all the softness of wax, the mild lustre even of the original polish. The finest Grecian sculpture which has been preserved to the present time is generally of Parian marble; as the Medicean Venus, the Diana Venatrix, the colossal Minerva (called *Pallas of Velletri*), Ariadne (called *Cleopatra*), and Juno (called *Capitolina*). It is also Parian marble on which the celebrated tables at Oxford are inscribed.

Pentelican marble, from Mount Pentelicus, near Athens, resembles, very closely, the preceding, but is more compact and finer granular. At a very early period, when the arts had attained their full splendour, in the age of Pericles, the preference was given by the Greeks, not to the marble of Paros, but to that of Mount Pentelicus, because it was whiter, and also, perhaps, because it was found in the vicinity of Athens. The Parthenon was constructed entirely of Pentelican marble. Among the statues of this marble in the royal museum at Paris are the Torso, a Bacchus in repose, a Paris, the throne of Saturn, and the tripod of Apollo.

Carrara marble is of a beautiful white colour, but is often traversed by gray veins, so that it is difficult to procure large blocks wholly free from them. It is not subject to turn yellow, as the Parian. This marble, which is almost the only one used by modern sculptors, was also quarried and wrought by the ancients. Its quarries are said to have been opened in the time of Julius Cæsar.

Red antique marble (rosso antico of the Italians; *Ægyptium* of the ancients). This marble, according to antiquaries, is of a deep blood-red colour, here and there traversed by veins of white, and, if closely inspected, appears to be sprinkled over with minute white dots as if it were strewed with sand. Another variety of this marble is of a very deep red without veins, of which a specimen may be seen in the Indian Bacchus, in the royal museum of Paris.

Green antique marble (verde antico of the Italians) is an indeterminate mixture of white marble and green serpentine. It was known to the ancients under the name *marmor Spartanum, or Lacedæmonium.—African breccia marble (antique African breccia).* It has a black ground, in which are imbedded fragments or portions of a grayish-white, of a deep red, or of a purple wine colour. This is said to be one of the most beautiful marbles hitherto found, and has a superb effect when accompanied with gilt ornaments.

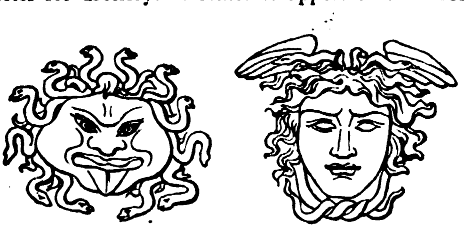
Its native place is not known with certainty; it is conjectured to be Africa. The pedestal of Venus leaving the bath, and a large column, both in the royal museum in Paris, are of this marble. (See NATURAL HISTORY Division of this work.)

MARCH; originally the first month of the Roman year, so named, according to tradition, by Romulus in honour of his father Mars. Till the adoption of the new style in England (1752), the 25th of March was new year's day; hence January, February, and the first twenty-four days of March have frequently two years appended, as January 1, 1701-2. (See CALENDAR.)

MARCH; a movement by regular steps in the manner of soldiers; also a journey performed by a body of soldiers either on foot or on horseback. Soldiers on a march are subject to certain rules, very necessary to keep them in good order, and fit to meet the enemy. The march in the first sense of regular step differs on different occasions. In the parade-march, from 75 to 95 steps, differing in different armies, are made in a minute; in the quick-march, from 108 to 115 steps; and, in the storming-march, 120 steps in the Prussian army.

March further signifies the music composed for such movements; it is composed in $\frac{4}{4}$ or $\frac{2}{4}$ time for the parade-march, and in $\frac{6}{8}$ for quick time. There are many sorts of such marches for festivals, funerals, &c., varying according to their different purposes.

MASK, or MASQUE; a cover to conceal the face. In the ancient revels the mask was considered an essential part of the costume; and even in the modern Italian carnival, as well as in our own masquerade attire, it retains all its peculiar character for drollery. Architects appear to have bor-



rowed some of their most singular and characteristic masques from the attire of those who were the principal actors in the "feasts of unreason." The left-hand sketch in the above engraving is copied from the porch of a Gothic edifice, and the lower part of the figure was dressed in the robes of a priest.

The other masque is copied from an ancient tomb; but the architects of the middle ages appear to have made most use of the mask in the erection of sacred edifices.

MASTIC; a resinous substance obtained from incisions made in the branches of the *pistachia lentiscus*, a small tree, or rather shrub, growing in the Levant and other countries bordering on the Mediterranean. This tree belongs to the natural family *terebinthaceæ*. It forms one of the most important products of Scio, and has been cultivated in this and some of the neighbouring islands from remote antiquity. Heat seems to exercise a great influence on the resinous product. Mastic is consumed in vast quantities throughout the Turkish empire, and is there used as a masticatory by women of all denominations, for the purpose of cleansing the teeth and imparting an agreeable odour to the breath. It was formerly in great repute as a medicine throughout Europe, but at the present time is very little used.

MATERIA MEDICA. See MEDICINE.

MATHEMATICS. If we call every thing which we can represent to our mind as composed of homogeneous parts a magnitude, mathematics, according to the common definition, is the science of determining magnitudes, i. e. of measuring or calculating them. Every magnitude appears as a collection of homogeneous parts, and may be considered in this sole respect; but it also appears under a particular form or extension in space, which originates from the composition of the homogeneous parts, and to which belong the notions of situation, proportion of parts, &c. Not only all objects of the bodily world, but also time, powers, motion, tones, &c., may be represented and treated as mathematical magnitudes. The science of mathematics has to do only with these two properties of magnitudes, the quantity of the homogeneous parts, which gives the numerical magnitude, and the form, which gives the magnitude of extension. This is one way, and the most common, of representing the subject: there are others more philosophical, but less adapted to the limited space which can allowed to so vast a subject, in a work like the present. In investigating these two properties of magnitudes, the peculiar strictness of the proofs of mathematics gives to its conclusions and all its processes a certainty, clearness, and general application, which satisfies the mind, and elevates and enlarges the sphere of its activity. According as a magnitude is considered merely in the respects above mentioned, or in connection with other circumstances, mathematics are divided into *pure* and *applied*. Pure mathematics are again divided into *arithmetic*, which considers the numerical quality of magnitudes, and *geometry*, which treats of magnitudes in their relations to space. In the solutions of their problems, the common mode of numerical calculations, and also *algebra* and *analysis*, are employed. To the applied mathematics belong the application of arithmetic to political, commercial, and similar calculations; of geometry to surveying, levelling, &c.; of pure mathematics to the powers and effects, the gravity, the sound, &c., of the dry, liquid, and aëriform bodies in a state of rest, equilibrium, or in motion—in one word, its application to the mechanical sciences; to the rays of light in the optical sciences; to the position, magnitude, motion, path, &c., of heavenly bodies in the astronomical sciences, with which the measurement and calculation of time, and the art of making sun-dials (see DIAL), are closely connected. The name of applied mathematics has sometimes been so extended as to embrace the application of the science to architecture, navigation, the military art, geography, natural philosophy, &c.; but in these connections it may be more conveniently considered as forming a part of the respective sciences and arts.

It is to be regretted that there is as yet no perfectly satisfactory work treating of the history of this science, so noble in itself, and so vast in its application: even Kästner and Montucla leave much to be desired. The establishment of mathematics on a scientific basis probably took place among the Indians and Egyptians. We find the first developement of the science among the Greeks, those great teachers of Europe in almost all branches. Thales, and more particularly Pythagoras, Plato, Eudoxus, investigated

mathematics with a scientific spirit, and extended its domain. It appears that geometry, in those ages, was more thoroughly cultivated than arithmetic. The ancients, indeed, understood by the latter something different from that which we understand by it. In fact, we have not a clear idea of the ancient arithmetic. Their numerical calculations were limited and awkward, sufficient ground for which might be found in their imperfect way of writing numbers, if there were no other reason. Euclid's celebrated *Elements* (a work of unrivalled excellence, considering the time of its origin), the ingenious discoveries of Archimedes, and the deep investigations of Apollonius of Perga, carried the geometry of the ancients to a height which has been the admiration of all subsequent times. Since then it has been made to bear more on astronomy, and has become more connected with arithmetic. Among the Greek mathematicians are still mentioned Eratosthenes, Conon, Nicomedes, Hipparchus, Nicomachus, Ptolemy, Diophantus, Theon, Proclus, Eutocius, Papus, and others.

It is remarkable that the Romans showed little disposition for mathematics; but the Arabians, who learned mathematics, like almost all their science, from the Greeks, occupied themselves much with it. Algebra and trigonometry owe them important improvements. Through the Arabians, mathematics found an entrance into Spain, where, under Alphonso of Castile, a lively zeal was displayed for the cultivation of this science. After this, it found a fertile soil in Italy; and in the convents a monk would sometimes follow out its paths, without, however, adding to its territory. This was reserved for later ages.

The science of mathematics owes much to Gmünden, Peuerbach, Regiomontanus, Pacciolo, Tartaglia, Cardanus, Macrolycus, Vieta, Ludolphus de Ceulen, Peter Nunez, Justus Byrge, and others. To this period, however, all mathematical operations of any extent required a weary length of detail; but, in the seventeenth century, Napier, by the introduction of logarithms, immensely facilitated the process of calculation; and Newton and Leibnitz, by their infinitesimal calculus, opened the way into regions into which no mathematician had previously attempted to penetrate. From this time, the science obtained a wonderful extension and influence, by the labours of such minds as Galilei, Torricelli, Pascal, Descartes, L'Hopital, Cassini, Huyghens, Harriot, Wallis, Barrow, Halley, James and John Bernouilli, and others. Thus it became possible for Manfredi, Nicoli, the two Bornouillis, Euler, Maclaurin, Taylor, Bradley, Clairaut, D'Alembert, Lambert, Tobias Mayer, Kästner, Hindenburg (the inventor of the combinatory analysis), Lagrange, Laplace, Legendre, Gauss, Bessel, and the later mathematicians in the eighteenth and in the present century, to make great advances, and to give us satisfactory conclusions, not only respecting our earth, but also the heavenly bodies, the phenomena and powers of nature, and their useful application to the wants of life, to establish firmly so many notions previously vague, and to correct so many errors.

The number of mathematical manuals increases daily, without, however, much surpassing the best of the earlier ones in perspicuity, novelty, and method, or rendering them unnecessary to the student.

May, the fifth month in the year, has thirty-one days. In the Salic laws, this month is called *Meo*, and it would appear that the idea of youthful beauty and loveliness, so naturally connected by northern nations with the month of May, gave rise to its name. In the Low Saxon, *Moj*, in Dutch, *Mooy*, is beautiful, agreeable; in Swedish, *Mio*, in Icelandic, *Mior*, small, pretty, agreeable; in ancient Swedish, *Mö*, a virgin (connected with *maid*, *maiden*). In Lower Brittany, *Mae* signifies green, flourishing, and *Maes*, a field, meadow; German, *Matte*; in Lorraine, *Io Mai*, and *Mé*, in ancient French, *Mets*, *Mès*, signify a garden. Whether all these must be referred to one Teutonic root, and whether this, again, is connected with the Indian *Maya*, the goddess of nature, cannot be investigated here.

Mean; the middle between two extremes: thus we say, the "mean motion of a planet," its "mean distance," &c., to signify a motion, or distance, which as much exceeds the least motion or distance as it is exceeded by the greatest. The *mean*, or *mean proportion*, is the second of any three proportions. In an arithmetical proportion, the *mean* is half the sum of the extremes; in a geometrical, the *mean* is the square root of the product of the extremes. *Mean time* is the mean or average of apparent time.

Measles; an exanthematic disease, which appears to have been unknown to the ancient physicians; the time of its first appearance in Europe is uncertain. It is communicated by the touch of infected persons or things. It is sometimes epidemic. Persons of all ages are liable to its attacks; but it is more common in infants, and rarely affects an individual a second time. The symptoms are hoarseness, cough, drowsiness, and, about the fourth day, an eruption of small red spots (hence the name *measles*; from the German *masern*, spots), which after three days end in scales. There is more or less of fever, attended with the usual febrile affections. The measles, even when violent, are not often of a putrid tendency, although such a disposition sometimes prevails. In the case of the simple measles, the best treatment is abstinence from food, and the use of mild, mucilaginous, sweetened drinks. Bleeding is proper only in the inflammatory measles. Some writers have treated the measles as an inflammation of the skin; but this is merely a symptom of the disease, and not the disease itself.

Measures. The general principle that simplicity and uniformity are the result of advancement in civilization is strikingly exemplified in the case of measures. Formerly every province, and almost every place of importance, had its own measures, which proved a most perplexing hindrance to commercial intercourse. In modern times, many attempts at uniformity have been made. Two modes most naturally suggested themselves, either to declare the measures of one place or province the universal measure (as has been done in this country, by an act of parliament, by which the standard London measures and weights are declared to be the standards for weights and measures throughout the realm), or to establish new measures, founded upon unalterable principles, upon the laws of nature, as has been done in France. Our standard yard is determined by the oscillations of a pendulum at London. This is still an arbitrary standard, as the oscillations vary in different parallels of latitude. It is not, indeed, so arbitrary as taking the foot of Louis XIV. for a measure, yet it is not so philosophical as the present French standard. The act already alluded to, for establishing uniform measures throughout the realm, and called the *act of uniformity*, took effect Jan. 1, 1826.

The system thus established is called the imperial

system. Its rationale is as follows :—Take a pendulum which will vibrate seconds in London, on a level parallel with the sea, in a *vacuum;* divide all that portion of the pendulum which lies between the axis of suspension and the centre of oscillation into 391,393 equal parts; then will 10,000 of those parts be an imperial inch, twelve whereof make a foot, and thirty-six whereof make a yard.

The standard yard is "that distance between the centres of the two points in the gold studs in the straight brass rod, now in the custody of the clerk of the house of commons, whereon the words and figures 'Standard yard, 1760,' are engraved, which is declared to be the genuine standard of the measure of length called a *yard;* and, as the expansibility of the metal would cause some variation in the length of the rod in different degrees of temperature, the act determines that the brass rod in question shall be of the temperature of 62° Fahrenheit. The measure is to be denominated the *imperial standard yard,* and to be the only standard whereby all other measures of lineal extension shall be computed. Thus the foot, the inch, the pole, the furlong, and the mile, shall bear the same proportion to the imperial standard yard as they have hitherto borne to the yard measure in general use."

The act also makes provision for the restoration of the standard yard, in case of loss, destruction, or defacement, by a reference to an invariable natural standard, which is to be that proportion which the yard bears to the length of a pendulum, vibrating seconds of time in the latitude of London, in a *vacuum* at the level of the sea; which is found to be as thirty-six inches (the yard) to 39.1393 (the pendulum); thus a sure means is established to supply the loss which might by possibility occur. Take a cube of one such inch of distilled water, at 62° of temperature by Fahrenheit's thermometer; let this be weighed by any weight, and let such weight be divided into 252,458 equal parts, then will 1000 of such parts be a troy grain; and 7000 of those grains will be a pound avoirdupois, the operation having been performed in the air. Ten pounds, such as those mentioned, of distilled water, at 62° of temperature, will be a gallon, which gallon will contain 277 cubic inches, and $\frac{274}{1000}$ parts of another cubic inch. The standard pound is determined to be that standard pound troy weight, made in the year 1758, in the custody of the clerk of the house of commons; such weight is to be denominated the *imperial standard troy pound,* and is to be "the only standard measure of weight from which all other weights shall be derived, computed, and ascertained; and one-twelfth part of the said troy pound is to be an ounce, and one-twentieth part of such ounce a pennyweight, and one twenty-fourth part of such pennyweight a grain; so that 5760 such grains shall be a pound troy, and 7000 such grains a pound avoirdupois, and one-sixteenth part of the said pound avoirdupois an ounce avoirdupois, and one-sixteenth part of such ounce a drachm."

If the standard pound shall be lost, destroyed, or defaced, the act directs that it shall be recovered by reference to the weight of a cubic inch of water; it having been ascertained that a cubic inch of distilled water, weighed in air by brass weights, at the temperature of 62° (Fahrenheit), and the barometer at thirty inches, is equal to 252,458 grains; and, as the standard troy pound contains 5760 such grains, it is therefore established that the original standard pound may be at any time recovered, by making another weight to bear the proportion just mentioned to a cubic inch of water.

The standard gallon is determined by the act to be such a measure as shall contain ten pounds avoirdupois of distilled water, weighed in air at the temperature of 62° (Fahrenheit), and the barometer at thirty inches; and such measure is declared to be the *imperial standard gallon,* and the unit and only standard measure of capacity to be used, as well for wine, beer, ale, spirits, and all sorts of liquids, as for dry goods not measured by heaped measure; and all other measures are to be taken in parts or multiples of the said imperial standard gallon, the quart being the fourth part of such gallon, and the pint one-eighth part, two such gallons making a peck, eight such gallons a bushel, and eight such bushels a quarter of corn, or other dry goods, not measured by heaped measure.

The standard for heaped measure, for such things as are commonly sold by heaped measure, such as culm, lime, fish, potatoes, fruit, &c., is to be "the aforesaid bushel, containing eighty pounds avoirdupois of water, as aforesaid, the same being made round with a plain and even bottom, and being nineteen and a half inches from outside to outside;" and goods thus sold by heaped measure are to be heaped "in the form of a cone, such cone to be the height of at least six inches, the outside of the bushel to be the extremity of the base of such cone."

Stricken Measure. The last-mentioned goods may be sold either by the heaped measure or by the standard weight, as before-mentioned; but for every other kind of goods not usually sold by heaped measure, which may be sold or agreed for by measure, the same standard measure is to be used, but the goods are not to be heaped, but stricken with a round stick, or roller, straight, and of the same diameter from end to end. Copies and models of the standard of length, weight, and measure, are to be made and verified under the direction of the treasury, and every county to be supplied with them for reference whenever required. Existing weights and measures may be used, being marked so as to show the proportion they have to the standard measures and weights; tables of equalization of the weights are to be made by the treasury; tables, also, for the customs and excise, by which the duties will be altered so as to make them equal to what they are at present, in consequence of the alterations in the weights and measures.

The measures now in use in the United States of America are precisely identical with our own; and it is creditable to the government of that country that they did not suffer any narrow-minded jealousy of the origin of this beautiful system to interfere with its adoption.

The following series of tables form a complete outline of our weights and measures, calculated from the London Standard.

1. MEASURE OF LENGTH.

12 inches	=	1 foot
3 feet	=	1 yard
5½ yards	=	1 rod, or pole
40 poles	=	1 furlong
8 furlongs	=	1 mile
$69\frac{1}{15}$ miles	=	1 degree of a great circle of the earth.

An inch is the smallest lineal measure to which a name is given, but subdivisions are used for many

purposes. Among mechanics, the inch is commonly divided into eighths. By the officers of the revenue, and by scientific persons, it is divided into tenths, hundredths, &c. Formerly, it was made to consist of twelve parts, called *lines;* but these have properly fallen into disuse.

Particular Measures of Length.

1 nail	= 2¼ inches		used for measuring cloth of all kinds.
1 quarter	= 4 nails		
1 yard	= 4 quarters		
1 ell	= 5 quarters		
1 hand	= 4 inches, used for the height of horses.		
1 fathom	= 6 feet, used in measuring depths.		
1 link	= $7\frac{92}{100}$ inches		used in land measure, to facilitate computation of the content, ten square chains being equal to an acre.
1 chain	= 100 links		

2. MEASURE OF SURFACE.

144 square inches	= 1 square foot
9 square feet	= 1 square yard
30¼ square yards	= 1 perch, or rod
40 perches	= 1 rood
4 roods, or 160 perches	= 1 acre
640 acres	= 1 square mile.

3. MEASURES OF SOLIDITY AND CAPACITY.

Division I.—Solidity.

1728 cubic inches	= 1 cubic foot
27 cubic feet	= 1 cubic yard.

Division II.

Imperial measure of capacity for all liquids, and for all dry goods except such as are comprised in the third division:

4 gills	= 1 pint	= 34⅔ cubic in., nearly
2 pints	= 1 quart	= 69⅓ ,, ,,
4 quarts	= 1 gallon	= 277¼ ,, ,,
2 gallons	= 1 peck	= 554½ ,, ,,
8 gallons	= 1 bushel	= 2218½ ,, ,,
8 bushels	= 1 quarter	= 10¼ cubic feet, nearly
5 quarters	= 1 load	= 51⅓ ,, ,,

The last four denominations are used for dry goods only. For liquids several denominations have been heretofore adopted, viz. for beer, the firkin of 9 gallons, the kilderkin of 18, the barrel of 36, the hogshead of 54, and the butt of 108 gallons.' These will probably continue to be used in practice. For wine and spirits, there are the anker, runlet, tierce, hogshead, puncheon, pipe, butt, and tun; but these may be considered rather as the names of the casks in which such commodities are imported than as expressing any definite number of gallons. It is the practice to gauge all such vessels, and to charge them according to their actual content.

Division III.

Imperial measure of capacity, for culm, lime, fish, potatoes, fruit, and other goods commonly sold by heaped measure :—

2 gallons	= 1 peck	= 704 cubic in., nearly
8 gallons	= 1 bushel	= 2815½ ,, ,,
3 bushels	= 1 sack	= 4 8-9 cubic feet, nearly

(For measures of weights, see Weights.)

5. ANGULAR MEASURE,

or Divisions of the Circle.

60 seconds	= 1 minute
60 minutes	= 1 degree
30 degrees	= 1 sign
90 degrees	= 1 quadrant
360 degrees, or 12 signs	= 1 circumference.

Formerly the subdivisions were carried on by sixties; thus the second was divided into 60 thirds, the third into 60 fourths, &c. At present, the second is more generally divided decimally into tenths, hundredths, &c. The degree is frequently so divided.

6. MEASURE OF TIME.

60 seconds	= 1 minute
60 minutes	= 1 hour
24 hours	= 1 day
7 days	= 1 week
28 days	= 1 lunar month
28, 29, 30, or 31 days	= 1 calendar month
12 calendar months	= 1 year
365 days	= 1 common year
366 days	= 1 leap year.

In 400 years, 97 are leap-years, and 303 common. The second of time is subdivided like that of angular measure. We shall now give a table of itinerary measures of different countries, exhibiting the number of each answering to 100 English miles; also the length of a single measure of each sort in English yards :—

		No. of each = 100 Eng. miles.	Length of a single meas. in Eng. yds.
Arabia,	Miles	81.93	2148
Bohemia,	,,	17.36	10137
Brabant,	,,	28.93	6082
Burgundy,	,,	28.46	6183
China,	Lis	279.80	629
Denmark,	Miles	21.35	8244
England,	,,	100.00	1760
	Geographical	86.91	2025
Flanders,	Miles	25.62	6869
France,	Leagues astronomical*	36.21	4860
	Do. marine	28.97	6075
	Do. legal, of 2000 toises	41.28	4263
Germany,	Miles geog.	21.72	8101
	Do. long	17.38	10126
	Do. short	25.66	6859
Hamburg,	Miles	21.35	8244
Hanover,	,,	15.23	11559
Hesse,	,,	16.68	10547
Holland,	,,	27.52	6395
Hungary,	,,	19.31	9113
India,	Cos	60.43	2894
Ireland,	Miles	57.93	3038
Italy,	,,	86.91	2025
Lithuania,	,,	18.00	9781
Oldenburg,	,,	16.26	10820
Persia,	Parasang, or farsang	27.33	6440
Poland,	Miles short	28.97	6075
	Do. long	21.72	8101
Portugal,	Legoas	26.03	6760
Prussia,	Miles	20.78	8468

* There are 25 leagues in a degree. A French post is equal to 2 leagues, or to 5.52 English miles.

		No. of each = 100 Eng. miles.	Length of a single meas. in Eng. yds.
Rome,	Modern miles	86.91	2025
	Ancient do. of 8 stadia	109.18	1612
Russia,	Versts	150.81	1167
Saxony,	Miles	17.76	9905
Scotland,	,,	88.70	1984
Silesia,	,,	27.67	7083
Spain,	Leguas common, of 800 varas	23.73	7416
	Do. legal, 500 varas	37.97	4635
Suabia,	Miles	17.38	10126
Sweden,	,,	15.04	11700
Switzerland,	,,	19.23	9153
Turkey,	Berries	96.38	1826
	Miles	80.05	1409

FOOT MEASURES

OF VARIOUS COUNTRIES REDUCED TO ENGLISH FEET.

	Eng. feet.
Amsterdam	.930
Antwerp	.940
Augsburg	.972
Barcelona	.992
Basle	.944
Berlin	.992
Berne	.962
Bologna	1.244
Bremen	.955
Breslau	1.125
Brussels	.902
China, mathem	1.127
China, imperial	1.051
Constantinople	2.195
Copenhagen	1.045
Cracow	1.169
Dantzic	.923
Dresden	.929
Florence	.994
Frankfort	.933
Hamburg	.993
Leghorn	.992
Leipsic	1.034
Leyden	1.023
Liege	.944
Lisbon	.952
Lyons	1.119
Madrid	.915
Marseilles	.814
Mentz	.988
Moscow	.928
Munich	.947
Nuremburg	.996
Padua	1.406
Palermo	.747
Paris	1.066
Prague	.987
Rhinland	1.023
Rome	.966
Stockholm	1.073
Strasburg	.956
Trent	1.201
Turin	1.676
Tyrol	1.096
Venice	1.137
Verona	1.117
Vicenza	1.136
Vienna	1.036
Ulm	.826
Urbino	1.162
Utrecht	.741
Warsaw	1.169
Wesel	.771
Zurich	.979

OTHER MEASURES,

REDUCED TO ENGLISH FEET.

Amsterdam ell	2.223
English fathom	6.000
French metre	3.198
French toise	6.396
Venice ell	2.089
Vienna ell	2.557

ANCIENT MEASURES.

Arabian foot	1.095
Babylonian foot	1.144
Egyptian foot	1.421
Greek foot	1.007
Hebrew foot	1.212
Hebrew sacred cubit	2.002
Hebrew great cubit	12.012
Roman foot	.965 to .970
Egyptian stadium	730.800
Roman mile of Pliny	4840.500
Roman mile of Strabo	4905.000
Pythian or Delphic stadium	576.877
The mean, or nautical, or Persian stadium	532.147
Great Alexandrian, or Egyptian stadium	710.659

JEWISH ITINERARY MEASURE.

	Eng. Miles.	Paces.	Feet.
Cubit	0	0	1.824
Stadium	0	145	4.6
Sabbath day's journey	0	729	3.0
Eastern mile	1	403	1.0
Parasang	4	153	3.0
A day's journey	33	172	4.0

The following comparative view of the weights and measures of England and France was published by the Royal and Central Society of Agriculture in Paris in their *Annuary* for 1829; and it may be proper to add that the above work contains a greater quantity of useful information than any other periodical in France.

MEASURES OF LENGTH.

English.	French.
1 inch (1-36th of a yard)	2 539954 centimetres
1 foot (1-3d of a yard)	3.0479449 decimetres
1 yard imperial	0.91438348 metre
1 fathom (2 yards)	1.82876696 metre
1 pole, or perch (5½ yd.)	5.02911 metres
1 furlong (220 yards)	201.16437 metres
1 mile (1760 yards)	1609.3149 metres
French.	**English.**
1 milimetre	0.03937 inch
1 centimetre	0.393708 inch
1 decimetre	3.937079 inches
1 metre	39.37079 inches
	3.2808992 feet
	1.093633 yard
1 myriametre	6.2138 miles

SQUARE MEASURE.

English.	French.
1 yard square	0.836097 metre square
1 rod (square perch)	25.291939 metres square
1 rood (1210 yards square)	10.116775 ares
1 acre (4840 yards square)	0.404671 hectares
French.	**English.**
1 metre square	1.196033 yard square
1 are	0.098845 rood
1 hectare	2.473614 acres

SOLID MEASURE.

English.	French.
1 pint (1-8th of a gallon)	0.567932 litre
1 quart (1-4th of a gallon)	1.135364 litre
1 gallon imperial	4.84345794 litres
1 peck (2 gallons)	9.0869159 litres
1 bushel (8 gallons)	36.347664 litres
1 sack (3 bushels)	1.09043 hectolitre
1 quarter (8 bushels)	2.907813 hectolitres

MECHANICS is the science which treats of forces and of motion. It had, probably, its origin in the construction of machines, and an important branch of it, practical mechanics, investigates their construction and effects. Forces acting upon bodies may either produce rest or motion. In the former case they are treated of under statics, in the latter under dynamics. Hydrostatics and hydraulics respectively treat of *fluids*, at rest or in motion.—When a body is acted on by two or more forces which counteract each other, so that no motion is produced, the body and the forces are said to be in a state of *equilibrium*. The conditions of equilibrium form the subject of statics. 1. A body acted upon by two equal and opposite forces will remain at rest. In this case either of the two opposite forces may be made up of several parallel forces. It is then said to be the *resultant* of those forces. 2. If two forces act with reference to each other obliquely upon a body, they may be counteracted by a third (called also their *resultant*). If the two forces be represented in direction and intensity by two contiguous sides of a parallelogram, their result will be represented in direction and intensity by its diagonal. This is called the *parallelogram of forces*. 3. If several forces, acting at once upon a polygon, can be represented in direction and intensity by several sides of a polygon, they may be counteracted by a single force, acting in a direction and with an intensity represented by the side which would be necessary to complete the polygon.

All the changes which come under our observation in this science are the consequence of motions produced by the action of a few great elementary forces. The consideration of the motions which take place among the particles only of one or of several bodies comes within the department of chemistry. Those motions which affect masses are the appropriate subject of the second part of mechanics.

All motions are found to take place in conformity to a few universal principles deduced from observation and confirmed by experiment. These principles have often been placed at the beginning of treatises on mechanics, under the name of the *laws of motion*. If not expressed in this manner, the truths they declare, making an essential part of the principles of the science, are necessarily introduced under some other form. Their comprehensiveness adapts them to our purpose, and they are here quoted in the language of Newton. I. "Every body perseveres in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed thereon." This is called the law of *inertia*, and expresses the entire indifference of matter to motion or rest. The proposition that a body will never begin to move of itself needs no proof: it is the conclusion of universal observation. Wherever we observe motion we conclude that there is a power in action to produce it. The other part of the law, that motion is, in its nature, as permanent as rest, and that it is in a right line, is far from being a self-evident, or even an obvious truth. Limited observation would lead to the conclusion that all matter has a tendency to rest, and such has long been, and still is, a common error. The same limited observation led some of the ancient astronomers to imagine that all bodies when forced into a state of motion naturally moved in curved lines. There is, however, abundant proof of the permanence of motion; and if friction and the resistance of the air, the two most universal obstacles to the motion of bodies near the surface of the earth, could be entirely removed, instances of permanent motion would be still more numerous. In proportion as they are removed, or as bodies are beyond their influence, we observe a tendency in the motions of those bodies to become more and more permanent. A marble, rolled on the grass, soon stops; on a carpet, it moves longer; on a floor, still longer; and on smooth level ice, where the wind is not unfavourable, it continues very long in motion. In a vacuum where the resistance of air is not felt, two windmills, whose pivots have equal friction, and which are set in motion by equal forces, continue to move equally long whatever be the position of their vanes. In the air, the one whose vanes cut the air will move much longer than the one whose vanes are opposed to it. A pendulum in a vacuum, having only the stiffness of the riband by which it is suspended to overcome, will vibrate for a whole day. A spinning top in the same situation, retarded only by the friction of its point, is said to continue spinning for hours. In all these cases the continuance of the motion is proportioned to the diminution of friction and resistance. We can hardly avoid the conclusion that a body once put in motion would, if left to itself, continue to move with undiminished velocity.

The heavenly bodies, moving in free space, subject to no opposing influence, keep on in their path with a velocity which has remained unabated since first they were launched from the hand of the Creator. They move not, indeed, in straight lines, but in curves, as they are drawn towards each other and towards a centre by the universal force of gravity. This force does not diminish their velocity, but deflects them continually from the right line in which they tend to move. If this central force were suspended, they would all shoot forwards into space, and the harmony of their motions would cease. Some force similar to this central tendency is always in action whenever we see bodies move in curve lines.

The stone to which a boy gives accumulated force by whirling it round in a sling is, for a time, kept in its circle by the central force represented by the string; when let loose it darts forward in the air, turning not to the right or left, until the atmospherical resistance destroys its motion, or the force of gravity bends it to the ground. A full tumbler of water placed in a sling, and made to vibrate with gradually

increasing oscillations, may at last be made to revolve in a circle about the hand, each drop tending to move out in a straight line from the centre, and therefore remaining safe in the tumbler, whose bottom is always farthest from the centre. In a corn mill the grain is poured gradually into a hole in the centre of the upper mill-stone. The weight of the stone pulverizes the corn, while its circular motion throws it out as fast as it is ground into a cavity around the stone.

When a vessel, partly full of water, is suspended by a cord, and made to turn rapidly round, the water, in its tendency to move out in a straight line, recedes from the centre, and is gradually heaped up against the sides of the vessel, sometimes even leaving a portion of the bottom dry. Water moving rapidly in the stream of a river, or the tide of the sea forced violently through a narrow passage between opposite rocks, not unfrequently forms a whirlpool on the same principle. Bent out of its course by a projecting ledge, it departs, as if reluctantly, from a straight line, and heaps itself up towards the circumference of the circle in which it is compelled to move. To this cause, too, it is owing, however little we might expect such a consequence, that a river, passing through an alluvial soil, and once turned from its onward channel, continues to pursue a meandering course to the sea. Driven, by any cause, to one side, it strikes the bank with all its violence, is repelled, and rebounds with the same force to the opposite side, continually wearing the two banks, and leaving a larger space on the inner side of the bends.

The force with which a body constrained to move in a circle tends to go off in a straight line is called the *centrifugal force*. Advantage is taken of it in many processes of the arts, and in all circular motions of machinery. The clay of the potter is placed on the centre of a swiftly revolving table, and while his hand shapes it the centrifugal force causes it to assume the desired dimensions. A globe, or sheet of molten glass, is in a similar manner made to expand itself. The legs of a pair of tongs, suspended by a cord, and made to revolve by its twisting or untwisting, will diverge in proportion to the velocity of the revolution.

The *steam governor* of Watt is constructed and acts on this principle. Weights are attached to two rods, to which a circular motion is communicated by the machinery which is to be governed. If the motion be so rapid as to cause these rods to diverge from each other beyond a certain angle, they act upon a valve which partly closes and diminishes the supply of steam. With a slower motion the rods collapse, and the valve is opened.

In consequence of the centrifugal force occasioned by the rotation of the earth, the weight of bodies at the equator is diminished the 289th part. If the earth revolved on its axis in eighty-four minutes, the loose parts near the equator would be projected from the surface. Another consequence or particular of the law of inertia is, that motion is communicated gradually. A force which communicates a certain quantity of motion in one second will impart double the quantity in two seconds. A ship does not yield at once to the impulse of the wind when the sails are set; its motion increases as new portions are successively imparted. A horse does not start at once with a carriage into his utmost speed; his force is at first spent in giving motion to the inert mass. Afterwards, with far less exertion, he keeps up the motion, being required to supply that portion only which is destroyed by the obstacles of the road. The motion communicated to a body, if not destroyed by some force, is accumulated. Thus a nail is driven in by all the force of the hand, accumulated through the whole time of the descent of the hammer. The knowledge of this fact gives the means of increasing the effective force of a moving power in a very great degree. A force of fifty pounds communicated every second to a loaded wheel will, if not diminished by friction or other cause of waste, enable it to overcome a resistance of five hundred pounds once in every ten seconds. Such a wheel is called a *fly wheel*.

II. "The alteration of motion is ever proportioned to the motive force impressed, and is made in the direction of the right line in which that force is impressed." This is only a statement that a double force generates a double motion; that motion cannot increase or diminish itself, nor turn to the right or left without cause. In consequence of this, two or more forces acting at once on a body in different directions cause it to take a direction different from that of either force, and, if one of them is a variable or constantly acting force, to move in a curve line. This is called the *composition of forces*, the single motion impressed upon the body being considered as composed of the several motions which the forces acting separately would have produced. A boat, rowed at the rate of three miles an hour directly from the bank of a river which runs at the rate of two miles an hour, is acted on at once by the force of the rowers and that of the current, and will be found, at the end of an hour, three miles from the bank, and two miles below the point from which it started, having moved in a diagonal line between the directions of the two forces.

The *resolution* of forces is the reverse of this. A single force is considered as resolved into two or more others. A ship, sailing on a side wind, is sent forward by a part only of its force. The other part has no effect, or that only of driving her out of her course.

III. "To every action there is always opposed an equal reaction; or the mutual actions of two bodies on each other are equal and in opposite directions." If you press a stone with your finger, the finger is equally pressed by the stone. A horse drawing upon a load is drawn backward by its whole weight, and, if he succeed in moving it, it can only be with a velocity proportioned to the excess of his strength over the reaction of the load. A magnet and piece of iron attract each other equally; and if, when in the sphere of mutual attraction, one is fixed and the other free, whichever is free will be drawn to the other. Two equal boats, drawn towards each other by a rope, act in the same manner; if both are free, they meet in the middle. When a gun is discharged it recoils with a force equal to that with which the ball is propelled, but with a velocity as much less as its weight is greater. If, in the side of a vessel of water, hanging perpendicularly by a cord, a hole be opened, the vessel will be pushed back from the perpendicular by the reaction of the jet of water, and will remain so while it flows. A consequence of this law is, that the earth is attracted by each body on its surface as much as it attracts, and that when a stone falls towards the earth the earth rises to meet it.—The force with which a body acts is estimated by its velocity and mass conjointly, and is called its *mo-*

mentum. Thus, if two balls of one and two pounds weight respectively be moving with the same velocity, the larger has twice the momentum of the smaller, since each pound of the larger has the same velocity as the ball of a single pound. A body of small weight may therefore be made to produce the same mechanical effect as a large one, by sufficiently increasing its velocity. The cannon ball of modern times is not less effectual in battering down walls than the massy battering-ram of the ancients.—The forces which may be employed to give motion to machines are called *mechanical agents* or *first movers*. They are water, wind, steam, gunpowder, and the strength of man and other animals. They may be indirectly referred to three independent sources—gravity, heat, and animal strength.

Gravity. A body falling from a state of rest descends 16 feet, nearly (16.095), in one second; but, as all the motion which is communicated by gravitation remains in it, and it receives an accession of motion every indefinitely small portion of the first second, it is moving more rapidly at the end of the second than at any previous time, and with that motion alone, if it continued uniform, would descend through twice sixteen or thirty-two feet in the next second; but during this next second as much motion is communicated as during the first, and consequently the body descends through three times sixteen or forty-eight feet in this next second. The whole of this accumulated motion would alone carry it through four times sixteen or sixty-four feet in the third second, and the continued action of gravitation carries it once sixteen; so that it actually descends five times sixteen or eighty feet during the third second. In the fourth second it would, in the same manner, descend seven times sixteen feet; in the fifth, nine times sixteen, &c., the series of odd numbers expressing the distances passed through in the successive seconds. By adding these numbers we find that at the end of two seconds the body will have descended four times sixteen feet; at the end of the third, nine times sixteen; at the end of the fourth, sixteen times sixteen, &c.; the whole distance fallen through at the end of any number of seconds being found by multiplying the square of that number by sixteen feet. Such is the simple and remarkable law of the descent of bodies by the uniformly accelerated velocity produced by gravitation. The velocity acquired in one second is sufficient of itself to carry a body through twice sixteen feet; that acquired in two seconds would carry it four times sixteen feet; that acquired in three seconds, through six times sixteen feet, &c., the velocities possessed at the end of any number of seconds being represented by twice that number multiplied by sixteen feet. The following table exhibits, 1. the space fallen through in the successive seconds; 2. the whole space fallen through at the end of a number of seconds; and, 3. the final velocity:—

Time, - - - -	1	2	3	4	5	6	7	8	9	10	seconds.
1. Successive spaces,	1	3	5	7	9	11	13	15	17	19	times 16 ft.
2. Total spaces, -	1	4	9	16	25	36	49	64	81	100	„ „
3. Final velocity, -	2	4	6	8	10	12	14	16	18	20	„ „

By means of this table, a traveller standing on the summit of a cliff might ascertain its height above the plain or torrent below, with considerable accuracy, by letting fall a stone and observing the time of its fall. It would only be necessary to make allowance for the resistance of the air, which, for small velocities, is not very great.

The same cause which communicates motion to a falling body would gradually destroy that of a body ascending. A ball projected upwards with the velocity of 1000 feet per second would, therefore, rise with a uniformly retarded motion to the height from which a body must fall to acquire that velocity. The phenomena of accelerated and retarded motion are beautifully exhibited by Atwood's machine for that purpose. In moving down an inclined plane, a solid body is urged by a portion of the force of gravitation, which is continually smaller as the plane is nearer to a horizontal position. When it is horizontal, the whole weight of the body is sustained by the plane. The velocity acquired by bodies moving down planes of different inclinations is the same as they would have acquired by falling freely through a distance equal to the perpendicular height of the plane. It is necessary, in the construction of machines, carriages, buildings, bridges, and ships, and in many other cases, to ascertain exactly the centre of gravity of the whole and of each part; since, if the centre of gravity, in any body or system of bodies, be supported, the whole must remain firm, and in a state of rest, in every possible position. The various problems arising from this necessity have been solved with great accuracy, and on fixed principles. In all regular solids of uniform density, whether bounded by straight or curve lines, the centre of gravity coincides with the centre of magnitude.

If a body of any shape be suspended freely from any one point of its surface, the straight line extending from that point to the centre of the earth will pass through the centre of gravity. This line is called the *line of direction*. The centre of gravity may, therefore, sometimes be found, practically, by suspending a body successively from two of its points, and observing the point where the lines of direction cross each other. The centre of gravity of a triangle is at one-third the distance from the middle of the base to the vertex; that of a cone and of a pyramid at one-fourth the same distance.

Stability, in every case, depends upon the position of the centre of gravity in reference to the base. The nearer it is to the base, and the further the line of direction falls from each part of the perimeter of the base, the greater is the stability. The sphere rests equally in every position, because the centre of gravity is at the same distance from every part of the surface; it is unstable in every position, as it rests on a single point of the plane; and it yields to the smallest force, as the centre of gravity does not rise when the sphere revolves. In order that the pyramid or cone may be overturned, the centre of gravity must rise almost perpendicularly, and move for a great distance before it ceases to tend to fall back to its place. Hence their stability, and hence the propriety of giving to steeples, monuments, and other buildings of great height, a pyramidical or conical figure. Those carriages are most secure which are hung low, and have the wheels far apart. Whatever raises the centre of gravity or narrows the base allows the line of direction more easily to pass without it, and consequently diminishes stability. Hence we see the imprudence of rising in carriages or boats which are in danger of being overset, and hence the danger of high loads on waggons, where the roads are not perfectly level. The force of gravity is not often employed directly as a mechanical agent, or prime mover. Those most fre-

quently employed to give motion to machinery are water, wind, heat, and the strength of animals.

Water acts by its *weight* and by the *velocity* which it acquires from falling, in consequence of its weight. *Wind* acts by its *volume* or *mass* and its velocity. Both these agents are variable, and both act in a straight line. *Heat*, as given out by combustible materials, produces steam or gas, or gives motion to air by making it lighter, and thus causing it to rise. The steam or gas, when formed, has a tendency to expand itself, presses against the sides of the vessel which contains it, and endeavours to escape with a force proportioned to the heat and pressure to which it is exposed. When allowed to escape in only one direction, it necessarily generates motion in a straight line. Steam, as usually employed, generates motion, which is alternately in one direction and the opposite. The strength of animals is commonly made to act upon some centre of resistance, by drawing, pushing, or pressing, and produces variable motions, naturally in a straight line, but often in a curve. The motions or pressures produced by all these agents are capable of being compared with those produced by weights. They might all be referred to a common standard, the unit of which should be the force required to raise a given weight a certain number of feet in a given time.

The mechanical agents are employed to measure time, to move ships and carriages, to raise weights, to shape wood and work metals, to overcome the resistance of air, of water, and of cohesion, to draw out and form materials, and to combine them into new fabrics. To apply them to accomplish any one of these effects requires the intervention of some mechanical contrivance. Such a mechanical contrivance, whether consisting of a few or of many parts, is called a *machine*. A machine has been defined, "a system of bodies, fixed or movable, so connected together that a movement impressed on one of them shall be transmitted to the others." The object of a machine is often vaguely supposed to be to produce or augment power. It can never have this effect. The resistance of the fixed and the friction of the movable parts will always consume a part of the power of the prime mover. The real object of every machine is to increase or diminish the velocity of the moving force, to change its direction, to accumulate its action and expend it at a single effort, to distribute the force among a great number of small resistances, or to divide the force of a resistance so that it may be overcome by a series of actions, or by the continued action of the moving power. A machine may combine the action of several movers, and employ one to regulate the others, so that the final effect shall be perfectly uniform. The pendulum, the governor, and the fly-wheel are employed for this purpose.

By the *mechanical powers* are signified the simple machines to which all machines, however complex, may be referred. They are essentially three in number, but usually considered as six; 1. The *lever*, and the *wheel* and *axis*; 2. the *inclined plane*, the *screw*, the *wedge*; 3. the *pulley*.

The *lever* is a bar, resting on a support, called a *fulcrum* or prop, for the purpose of raising, by a *power* applied to one end, a *weight* at the other. An iron crow, used by workmen to raise heavy stones, affords a good instance of a lever. The stone is the weight; the block on which the crow rests is the fulcrum; the strength of the men, the power. To gain any advantage by its use, the fulcrum must be nearer to the weight than to the power. If the distance from the power to the fulcrum be five times greater than the distance from the weight to the fulcrum, a force of one pound in the power will balance a pressure of five pounds in the weight. But in this case the end of the long arm of the lever will, as it turns on the prop, pass through a space five times greater than that of the short arm. By such a lever a man could raise 1000 pounds with the same exertion as would be required to raise 200 without a lever, but he could raise it only a fifth part so high in the same time. What he would gain therefore in power would be lost in time. In theory, a lever is considered inflexible and without weight. There is an equilibrium when the power and weight are inversely as their distances from the fulcrum.

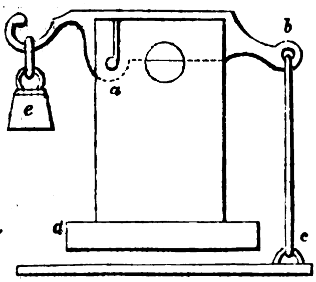
Leverage is the distance of the power from the fulcrum. The *mechanical advantage* or *purchase* is proportional to this distance compared with that of the weight from the fulcrum. Levers are of three kinds, according to the relative position of the power, the prop, and the weight. In the first, the prop is between the power and the weight. To it belong scissars, snuffers, pincers (in which the pivot or joint is the prop), the hand-spike, the brake of a pump, &c. A hammer with its claw is a bent lever of this kind. In the second, the weight lies between the fulcrum and the power. This includes the oar, where the boat is the weight to be moved; the door, of which the hinge is the fulcrum; the wheel-barrow, nut-crackers, bellows, and the knife attached at one end, used to chip dye-woods. In a lever of the third kind, the resistance is at one end and the fulcrum at the other. To this belong the pitchfork and spade, the one end being the power and the other the fulcrum, sheep-shears, with a bow at one end, giving a greater facility of motion. The bones of animals are levers of this kind, and are moved by muscles so attached as to give rapidity of motion at the expense of power. The ox-yoke is of this kind, the neck of each ox being the fulcrum with reference to the exertion of the other. The stronger of two oxen must have the short arm of the lever, that they may be able to pull together. So a load supported on a pole and borne by two men must divide the pole unequally, if either is to be favoured.—The mechanical advantage may be multiplied to any extent by a combination of levers of the first kind. Such a combination is used to *prove* the strength of iron cables.—To the lever are referred the various instruments employed for weighing. The most perfect of these is the common *balance*. For entire accuracy, the arms should be of precisely the same length, and as nearly as possible inflexible, light, and strong. The axis on which it turns, and the points of suspension at the ends of the arms, should be sharp, and rest upon polished plates of steel.

If we wish to construct a balance with the least possible degree of friction, this form of the lever should be adopted, but, instead of allowing it to rest on a flat plane, the fulcrum should be formed of steel and suspended by a magnet. By adopting this plan, the friction diminishes as the weights placed in the scale-pans are increased, an effect exactly the reverse of that which results from the use of the ordinary balance.

The Editor of this work has a specific gravity balance arranged upon this principle, which turns

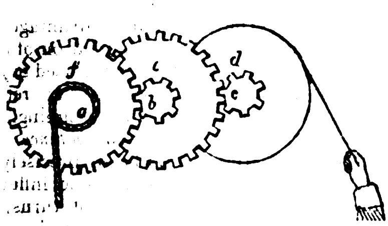
freely with the eight hundredth part of a grain, and yet the first cost was little more than that of a common pair of scales.

In the accompanying figure we give a view of a combination of levers in which great power is obtained. It is intended for pressing and cutting of metal. The principal lever, placed at the top of the machine, revolves on the axis or fulcrum *a*, which must be immovable and of great strength. The point *b* is just three times as far from the axis *a* as the pressing orifice is. A rod descends from the point *b*, and carries the mechanical advantage thus obtained to the lever beneath, and, as that turns on an axis placed at the extremity, a pressing power applied at the end of the longer arm *d* will act with an amazing force on the cutting part of the machine. The weight *e* is intended merely to raise the levers after the power is withdrawn.



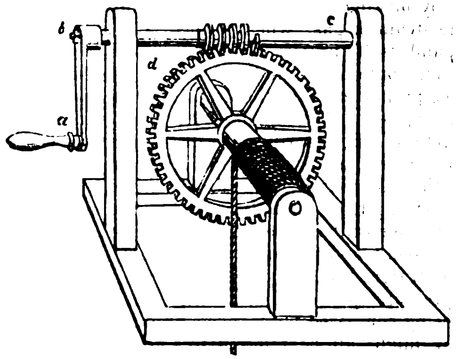
The *wheel* and *axle* consist of a wheel attached to a smaller cylinder, and moving on the same axis. The weight to be raised has a cord winding round the cylinder, and the power is attached to the circumference of the wheel. It may be regarded as a continual lever, each spoke of the wheel representing the long arm, and the radius of the cylinder the short arm. The mechanical advantage depends on the ratio of the cylinder. In the *ship's windlass*, movable bars or hand-spikes are substituted for a wheel. The *capstan* is a vertical wheel and axle used on board ships to weigh the anchor.

The wheel and axle may turn on different centres, and have their circumferences connected and made to act on each other, by means of a strap or belt, or by a system of cogs or teeth. The latter plan is adopted in this arrangement, and is called *wheel and pinion work*.



The weight to be raised is supported by a flexible cord coiled round the axis *a*; and, as the teeth of the wheel are three times as far from the centre as the cord, one pound will raise three pounds. In the wheel and pinion *e b* a similar advantage is obtained, and nine pounds may be elevated. Passing on to the third in the series, twenty-seven pounds may be raised by a maintaining power of one pound applied by the hand.

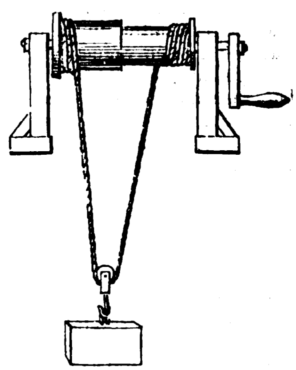
Another example, and a still more striking one, is given in the wheel and axis *a b c d*. The power is in the first instance applied at the handle *a*, which acts on the screw *b c* with great force. The screw turns the wheel *d*, and that gives motion to the small barrel. The handle at *a* will raise a weight of ten pounds at the screw, and, if that make forty revolutions to one of the wheel, four hundred pounds may be raised. It may hardly be necessary to add that, as the barrel is smaller than the wheel, the mechanical advantage is proportionably increased.



The efficacy of the wheel and axle may be increased either by enlarging the diameter of the wheel or diminishing that of the cylinder.

The *Chinese capstan* furnishes the means of increasing the mechanical efficacy to any degree. It consists of two cylinders of nearly equal diameters, turning upon the same axis, the weight being supported by the loop of a very long cord, one end of which unwinds from the smaller cylinder, while the other end is coiled upon the larger. The elevation of the weight by each revolution is equal to half the difference of the two circumferences, the mechanical advantage depending upon the smallness of this difference.

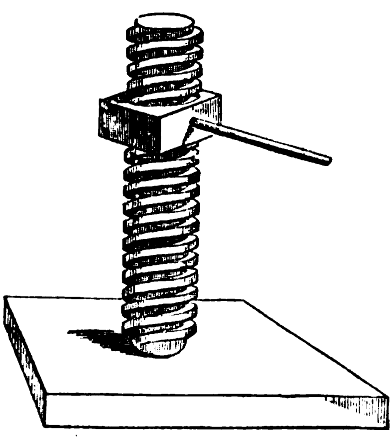
An arrangement of this kind is shown in the accompanying figure. One end of the cord coils round the first cylinder, and descending passes under the pulley to which the weight is attached. It is then carried around the smallest cylinder, and the apparatus may either be made to draw in a horizontal or vertical direction.



Inclined plane.—When a drayman lays a plank from the street to the higher level of the floor of a store-house, that he may be able to roll in a heavy cask, he employs the principle of the *inclined plane*; and the more gradual the inclination of the plank the more easily will he effect his purpose: that is, the advantage gained by the inclined plane is greater the more the length of the plane exceeds its height. A road which is not level is an inclined plane. When a road mounts over a hill, instead of winding round its foot, a team of horses with a load of a ton weight must exert strength sufficient to lift the load perpendicularly into the air, to a height equal to that of the top of the hill, instead of that moderate

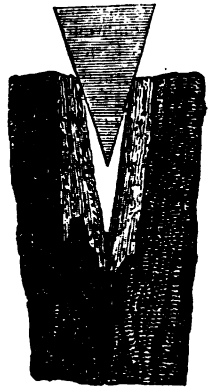
exertion which is necessary to overcome the friction of the axis of the waggon and the slight inequalities of a level road. Hence the absurdity of constructing roads in hilly countries to pass directly over the tops of hills, instead of winding by small circuits along their base. A body descending freely on an inclined plane moves with a velocity as much less than that with which it falls freely as the height of the plane is less then the length. If the elevation were one-sixteenth of the length, the body would roll down one foot in the first second, and four in twice that time. It is on this principle that the equality in the vibrations of a pendulum may be explained. A long vibration takes no more time than a short one, because the body begins to fall in this case down a steep plane, and acquires great velocity. In a short vibration, the beginning of its path is a very gradual descent. A short pendulum vibrates more rapidly than a long one, because it has a shorter distance to move in a path of the same steepness. A body moving down an inclined plane moves four times as far in two seconds as in one. A pendulum, to vibrate once in two seconds, must be therefore four times as long as one which beats seconds. The most remarkable application of the inclined plane is in the construction of the *marine rail-way*, on which, by the power of a few horses, a ship of 600 tons is drawn, with all its cargo, out of the water, high enough to allow workmen to pass under its keel. An example of this species of mechanical power has already been given under INCLINED PLANE.

The *screw*. Imagine an inclined plane to pass round an immense building like the tower of Babel, affording means of ascending to the top, and you have the first idea of the *screw*. It is an inclined plane wrapped spirally round a solid cylinder. The advantage gained by it depends on the slowness of the ascent, that is, on the number of turns, or *threads* as they are called, in a given distance. It is always used in combination with a lever. It is a machine of great power, commonly employed to produce compression or to raise heavy weights. In the screw beneath, the threads which form the path of the inclined plane are flat, instead of being sharp as in the common wood screw, and this form is well fitted for heavy work, as it materially reduces the friction.



Hunter's screw is a compound of two screws with threads of different degress of fineness, one moving within the other, the end advancing at each revolution through a distance equal to the difference of the threads. (See SCREW.)

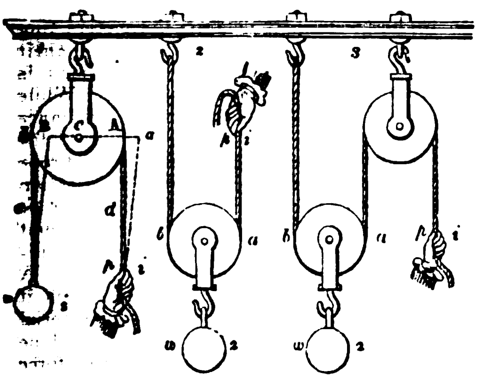
The *wedge* is a double inclined plane, used commonly to cleave wood or stone, and sometimes to elevate a large mass, as part of a building or a ship. The effect of a wedge depends apparently upon friction, elasticity, and the slowness with which motion is communicated to a mass of matter. When a wedge is driven in the particles immediately in contact with it are, for a moment, displaced: the friction against it prevents it from receding, and when the displaced particles endeavour to resume their relative position the rift is lengthened, as is shown in the wood cut. To the wedge may be referred various cutting tools, such as axes, knives, swords, chisels, and nails and spikes to be driven into wood, as well as pins, needles, awls, &c. The saw and the file and rasp are modifications still more remote. The colter of a plough, the blade of a spade, and other instruments to penetrate the earth, are in the shape of a wedge.



The *pulley*. If a rope be stretched horizontally between two fixed points by equal weights attached to the ends, any very small weight applied to the rope between these points will bend the rope and thus raise the weights. If we suppose the rope to have been perfectly horizontal, the weight applied acts upon those at the ends with a mechanical advantage which may be considered infinite, as it acts at right angles to the directions of the opposite actions of those weights. This is a necessary consequence of the principles of the resolution of forces. The action of one or two forces can have no effect in counteracting a third, unless they act in such a direction that their action can be resolved into two, one of which is opposite to the direction of the third force. While the rope is horizontal the two weights counterbalance each other, but produce no further effect until the rope is bent into an angle. A bending of the rope must therefore take place in consequence of the action of any force, however small. By bending the rope it must raise the weights and support them at a point above their former position, thus producing an equilibrium with them however great they may be. A necessary consequence of the principle on which it depends is, that when a rope or chain of any material whatever is stretched horizontally its weight alone will prevent its being perfectly straight, and no force is sufficient to straighten a rope unless it hangs perpendicularly. Advantage is often taken of this power by seamen in tightening ropes, which have previously been drawn as closely as possible by the direct action of their strength.

The flexible rope to which we have adverted is an essential part of the pulley, which is a small wheel, moving on an axis or pin, fixed in a frame called a *block*. The circumference of the wheel has a groove for the rope to move in. The pulley is said to be *fixed* or *movable*, according as its block admits of motion or not. A fixed pulley gives no mechanical ad-

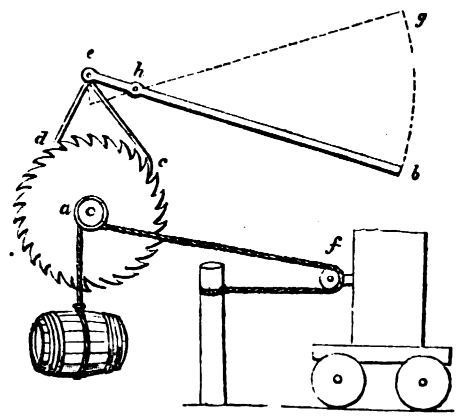
vantage, but it enables us to apply force more conveniently, by changing its direction. A man standing on the deck of a ship is able, by means of one fixed at the top of the mast, to raise a weight to that point by drawing downwards. In the same manner ore is raised from mines, and water from deep wells. The wheel in the grooved circumference round which the rope passes gives facility to its motion by preventing the necessity of its bending suddenly round a sharp edge, and diminishes the friction by transferring it from the rope to the axis of the wheel. One or more grooved wheels, called *sheaves*, set in a block, and moving freely round an iron axis, constitute a pulley, and the combination of pulley and ropes a *tackle*. If the rope, instead of being attached to the weight, passes through a movable pulley attached to the weight, and terminates in a hook or ring in the upper block, the tackle becomes an engine by which another advantage is gained. As, in this case, the weight is supported by two parts of a rope, each part sustaining one-half, the power necessary to support one of these parts is equal to only one-half the weight supported, and, by drawing upon one end of the rope with a power a little greater than one-half of the weight, the whole weight will be raised. It is on this principle that advantage is gained by the pulley. If the weight were supported by the four parts of a rope, which passed through two fixed and two movable pulleys, each part sustaining one-fourth of the weight, a power equal to one-fourth part of the weight, attached to the free end of the rope, would balance the whole weight, and something more than one-fourth would raise it. This advantage is purchased by the space through which the power must move, and the time occupied by the motion. To raise a weight fifty feet, by the combination last mentioned, the power must move over a space of 200 feet. The pulley is employed to elevate large weights to the tops of buildings, or to upper lofts in store-houses. Its numerous varieties are chiefly used on board ships.



An example of the simplest form of the pulley is given at B A, in which a weight, *w i*, is supported by the hand *p i*. The pulley in this case serves merely to change the direction of motion. If we suppose a second pulley to be attached to the first, as much larger as is shown by the dotted line, or rope *a*, the effect would be doubled, as in the common wheel axle. In figure 2, the same mechanical advantage is obtained by a single pulley. The cord passes round the pulley *a b*, and the weight of two pounds is supported by a power of one applied by the hand at *p i*. To understand this, it will only be necessary to bear in mind that the axis of the pulley to which the weight is really attached is only half the distance from the flexible fulcrum *b* that the point *a* is to which the power is applied. In the third series we have the same arrangement of the left-hand pulley, but the power is applied through the medium of a roller at top, which is employed only to change the direction of motion.

A great many experiments made by Rondelet have shown that, for most purposes, the best proportions for the wheel of a pulley are, 1. that its diameter should be five times its thickness; 2. that the diameter of the pin should be one-twelfth of that of the wheel; 3. that the wheel should have about one-twelfth of its thickness on each side for its play in the block.

In concluding our account of the mechanical powers, it may be advisable to take one machine in which several are combined. The lever *b*, by moving through the arc *b g*, tends to elevate the barrel attached to the cylinder *a*. This is effected by the two arms *d* and *c*, which are attached by a flexible joint to the end. When the end of the lever *b* is elevated, then the arm *d* carries forward the wheel a single tooth. When it is depressed, *c* moves the wheel. The same machine may be employed to do other work, and when combined with a pulley, as at *f*, its power is doubled.



MEDALLIONS. The term *medallion* is applied to those productions of the mint which, if gold, exceed the *aureus* in size; if silver the *denarius*; and if copper the first or large brass coin. Antiquaries have long differed as to the purposes for which they were designed; they are generally, however, supposed to have been struck, like the medals of our time, to commemorate some remarkable event. Yet circumstances are not wanting to render it probable that they were intended for circulation as money. Perhaps both objects were united, at least in many instances, a large number of pieces, of a definite value, being coined in memory of a great event, and thus adapted, at the same time, for current use. Medallions are not numerous. The Greek, or those struck in the Greek provinces of the Roman empire, are more common than the Roman, but of inferior workmanship. A gold medallion exists of Augustus, and one of Domitian; but few, in any metal, are found prior to the reigns of Adrian and Antonine; those in brass are

the largest, many of them being several inches in diameter.

MEDALS. See NUMISMATICS.

MEDICINE; the science of diseases, and the art of healing or alleviating them. It is founded on the study of man's physical and moral nature, in health and in disease. Like other sciences, medicine has gained more from the single discoveries of close observers than from centuries of theory. For the few hundreds of years in which men have begun to apply themselves more to actual observation, and the human body has been carefully studied, medicine, like all the natural sciences to which it is so near akin, has made great progress.

The higher kinds of skill and knowledge, in the earlier stages of nations, are in general exclusively appropriated by the priests, and this has been the case with medicine and the other branches of natural science. The knowledge of medicine was a secret of the Egyptian priests, and, in Greece, it was carefully concealed, and transmitted from father to son by the family of the Asclepiades, an order of priests of Æsculapius. To these belonged the great Hippocrates. He undertook, in the fifth century B. C., after making himself master of the medical knowledge preserved in the temples at Cos and Cnidos, to become the founder of scientific medicine, by separating the results of actual experience from vain speculation. His doctrine may be called the *empiric rationalism*; and numerous as are the systems that have flourished since, in ancient and modern times, mankind has always returned to his principle of making observation the only rule in the treatment of diseases. The doctrine of Hippocrates was blended, by his immediate successors, with the Platonic philosophy, whereby was formed the (so called) *ancient dogmatic system*. In Alexandria, which was, from 300 B. C., the seat of learning, medicine was one of the branches studied, but soon degenerated into mere dialectics and book-learning. Hence we find it soon followed by the empiric school (286 B. C.), the methodic school (100 B. C.), the pneumatic school (68 B. C.), and at length by the eclectic school (A. D. 81), which took from all the others. A philosophical and great mind was required to put an end to so confused a state of medical science, and such a mind appeared in Galen of Pergamos. His system acquired an almost undisputed preëminence during the middle ages, and down to the sixteenth century.

For some time the intellectual Arabians cultivated the sciences, and with them medicine. They also founded their medicine on that of Galen, but fashioned the science according to their notions, and left it not unimproved in respect of practical application and pharmacology. Arabian medicine reached its highest point under Avicenna (born 980), who was esteemed even higher than Galen; the opinion of the latter's superiority, however, eventually revived. Western medicine begins with the medical school of Salerno, perhaps existing as early as in the ninth century, but well established in 1143 and 1238, when medicine was taught according to the principles of the Greeks. During the rest of the middle ages there existed a Galeno-Arabian science of medicine, mostly fostered by ignorant monks, and only gradually struggling on, after suffering, perhaps more than any other science, from every superstition and every misconception of nature. In the fourteenth century anatomy was improved by Mondini; later, the knowledge of medicaments by the discovery of new and distant countries, practical medicine by the appearance of new diseases, and not a little by the frightful syphilis. The love of Greek literature was revived by the scholars driven from Greece by the conquest of Constantinople (in 1453); and men having begun to read the Greek medical writers, especially Hippocrates, in the original language, a more scientific and liberal spirit of investigation took the place of slavish adherence to antiquated prejudice. Thus the fall of the Galenic system was prepared, which was completed in the sixteenth century, and forms the essential part of the reformation produced by Theophrastus Paracelsus (1526). Soon after Harvey's great discovery of the circulation of the blood (in 1619) the medico-mathematical doctrine, under Alphonso Borelli (who died in 1679), developed itself, which finally took the shape of the dynamic system of Fr. Hoffman, from which the dynamic schools of modern times proceeded. For the newest systems, as the homœopathic system of Hahnemann (see HOMŒOPATHY), or that of M. Broussais, a Frenchman, who strives to trace all diseases to inflammation of the bowels, we must refer to the publications of those authors, and to the medical periodicals. The various medical sciences, or those closely connected with them, and more or less requisite for a thorough knowledge of medicine, may be thus enumerated:—The whole range of natural sciences, as zoölogy (including comparative anatomy and physiology, mineralogy, geology, botany, natural philosophy, chemistry, &c.)—psychology, which teaches the various phenomena of soul and mind—anatomy, which teaches the form and situation of the organs by the examination of dead bodies, and is divided into osteology, treating of the bones; syndesmology, of the ligaments; myology, of the muscles; splanchnology, of the intestines; angiology, of the vessels; neurology, of the nerves; and adenology, of the glands—organic physics, treating of the mechanical operations of the human body, the power, gravity, &c., of its parts—physiology, which treats of all the phenomena of life in connection. Such is the basis of all those branches of science which may be more particularly called *medical*, and which we will now enumerate. The science of health, that is, of that in which it consists, its conditions, and its signs, is called *hygiene*, or, as far as it relates to the regulation of the diet, *diætetics*. *Pathology*, on the other hand, is the science of disease, of that in which it consists, its origin, &c. *Nosology* treats of the various sorts of diseases, their origin and symptoms, and strives to arrange diseases into one whole. *Pathological anatomy* teaches the mechanical alterations and changes of structure. *Semiotics* teaches to infer from the various symptoms the nature of the disease; *diagnostics*, to distinguish the symptoms of different diseases; and *prognostics*, to infer from the past and present state of a disease its future course. *Therapeutics* is the science of the cure of diseases, often divided into *general*, treating of the subject of cure in general, its character, &c., and *special*, of the cures of the particular diseases.

Surgery treats of mechanical injuries, and the mode of relieving diseases and derangements by mechanical means. *Obstetrics* treats of the modes of facilitating delivery. *Materia medica* is the science of medicines, their external appearance, history, and effects on the

human organization. *Pharmacy* teaches how to preserve drugs, &c., and to mix medicines.

Clinics, or medical practice, applies the results of all these sciences to real cases. We should mention in this connection the history and literature of medicine; the history of diseases; a very interesting branch, political medicine, which is divided into medical police and forensic medicine, that branch which enables the physician to give to courts and other legal authorities proper explanations in regard to personal injuries, particular appearances of the body, &c., as whether a wound was mortal, how inflicted, whether a child was dead before born, &c. In many countries physicians are appointed by the government for this purpose.

Mellitic Acid; discovered by Klaproth in the mellite, or honey-stone. It is procured by reducing the mellite to powder, and boiling it with about seventy-two times its weight of water; the alumine is precipitated in the form of flakes, and the acid combines with the water. By filtration and evaporation, crystals are deposited, in the form of fine needles, or in small short prisms. It is composed of carbon, hydrogen, and oxygen. In combination with the earthy alkalies and metallic oxides, it forms compounds called *mellates*.

Melody; in the most general sense of the word, any successive connection or series of tones; in a more narrow sense, a series of tones which please the ear by their succession and variety; and, in a still narrower sense, the particular air or tune of a musical piece. By melody, in its general, musical sense, the composer strives to express particular states of feeling or disposition, which, in pieces of several voices, is chiefly effected by the principal melody, or chief voice, to which the other voices, with their melodies, are subordinate. The elements by which the composer is enabled to express a beautiful variety of sentiments and feelings, by means of the melodious connection of tones, are the variety of tones in themselves, and the variety of transitions from one tone to another, to which is still to be added the variety of the movements in which the music proceeds.

Melody and rhythm are the true means to awaken delight, and, where they are wanting, the greatest purity of harmony remains without effect. The proper essence of melody consists in *expression*. It has always to express some internal emotion, and every one who hears it, and is able to understand the language, must understand the feeling expressed. But as melody, in the hands of the composer, is a work of art and taste, it is necessary that, like every other work of art, it should form a whole, in which the various means are combined to produce one effect. This whole must be such that the hearer is kept constantly interested, and can give himself up, with pleasure, to the impressions which he receives. The particular qualities of a good melody are these:—It is indispensable that it should have one chief and fundamental tone, which receives proper gradations by a variation adapted to the expression. This can be effected only by letting the tones proceed according to a certain scale; otherwise there would be no connection between them. The chief tone, again, must be appropriate to the general idea to be expressed, because every kind of tone has its own character, and the finer the ear of the composer is the better will he always discover the tone wanted.

In very short melodies, or tunes consisting merely of a few chief passages, the same fundamental tone may remain throughout, or perhaps pass over into its *dominante*; but longer pieces require change of tone, that the harmony also may receive modifications according to the feeling. Thirdly, a good melody requires rhythm. A regular advance from one part to another, whether in music or motion (dancing), affects the mind agreeably, whilst an irregular progress fatigues. The love of rhythm is one of the most general feelings of human nature. We find rhythm every where, and to music it is indispensable, as tones without regularity of measure would distract and weary. Hence music is divided into portions or bars; these, again, are divided so as to prevent monotony, without disturbing the general regularity. Accents are given to certain parts, and it is possible greatly to assist the expression of feeling by slow or quick, gay or solemn movements, and by the variety of accents, and even or uneven time.

Much might be said respecting the skill of the composer to adapt his music, not only in general to the idea to be expressed, but also, in song, to the single words, to the pause which the hearer wishes here, or the speedy movement which he desires in other places; the necessity of the repetition of words, if the feeling is long and varied, while the word is short; the childish impropriety of representing, as it were by imitative sounds, the ideas presented by particular words, which is much the same as if a declaimer, every time that he pronounces the word *ocean*, were to endeavour to represent the roaring of the waves; the parts where dissonances are admissible, &c.; but it would carry us much beyond our limits.

Menses; periodical discharges to which females are subject during a certain portion of their life.

Mensuration is the art of ascertaining the contents of superficial areas or planes, of solids or substantial objects, and the lengths, breadths, &c., of various figures, either collectively or abstractedly. The mensuration of a plane superficies or surface lying level between its several boundaries is easy: when the figure is regular, such as a square or a parallelogram, the height, multiplied by the breadth, will give the superficial contents. In regard to triangles, their bases, multiplied by half their heights, or their heights by half their bases, will give the superficial measure. The height of a triangle is taken by means of a perpendicular to the base, let fall from the apex or summit. Any rectangular figure may have its surface estimated, however numerous the sides may be, by simply dividing it into triangles by drawing lines from one angle to another, but taking care that no cross lines be made: thus, if a triangle should be equally divided, it may be done by one line, which must, however, be drawn from any one point to the centre of the opposite face. A four-sided figure will be divided into two triangles by one oblique line connecting the two opposite angles; a five-sided figure (or pentagon) by two lines, cutting, as it were, one triangle out of the middle, and making one on each side; a six-sided figure (or hexagon) will require three diagonals, which will make four triangles; and so on, to any extent, and however long or short the several sides may be respectively.

The most essential figure is the circle, of which mathematicians conceive it impossible to ascertain the area with perfect precision, except by the aid of logarithmic and algebraic demonstration. It may be

sufficient in this place to state that 8$\frac{86}{100}$ of the diameter will give the side of a square whose area will be correspondent with that of a circle having ten for its diameter. Many circular or cylindrical figures come under the measurer's consideration—mirrors, arched passages, columns, &c. The contents of a pillar are easily ascertained, even though its diameter may be perpetually varying; for if we take the diameter in different parts, and strike a mean between every two adjoined measurements, and multiply that mean area by the depth or interval between the two, the solid contents will be found.

The contents of pyramids are measured by multiplying the areas of their bases by half their lengths, or their lengths by half the areas of their bases. Cones whose sides are straight are equal to one-third the solid contents of cylinders equal to them in base and altitude. Solids which have a certain degree of regularity may be easily measured: thus a cube is computed by multiplying first its width by its length, then their product by its height: thus a cube measuring four feet each way would be $4 \times 4 = 16 \times 4 = 64$. This is the meaning of what is called the *cube root*.

Parallelopipedons, or solids of a long form, such as squared timbers, are measured by the same means.

For the mensuration of growing timber various modes have been devised. After a tree has been felled its girth is usually taken at each end and at the middle, when there is no particular swell or the top extremity does not suddenly decrease. But where the irregularity is great it is better to take many more girths, and, summing up the whole, to divide their amount by the number of girths taken, so as to establish a mean measurement. Divide that mean measurement by four to find the side of a square to which the tree will be reduced when prepared for the sawyer. If the whole solid contents are to be estimated, divide by three instead of four, and taking the third part, thus given, for a diameter, proceed in the way already shown to find the side of a square equal to the circle of which that ascertained third part is the diameter. Solid bodies or areas, such as hay-stacks, interiors of barns, granaries, &c., come under the rule laid down for cubes, &c. When any sides fall in regularly, as in garrets, &c., the inclined part must be treated as a pyramid, or as a quoin (or wedge), and the whole be summed up together. The contents of casks, tubs, &c., are found by the process of gauging. (For that part of the subject which appertains to the admeasurement of lands, as also to the distances, heights, &c., of remote objects, accessible or otherwise, see SURVEYING.)

MENTAL DERANGEMENT, INSANITY. By these general terms we understand every form of intellectual disorder, whether consisting in a total want or alienation of understanding, as in idiocy, or in the diseased state of one or several of the faculties. Medical writers have adopted different systems of classification in their treatment of this subject; but perhaps the most convenient is that which comprises all mental diseases under the four heads of mania, melancholy, demency or fatuity, and idiocy. Lunacy, in its proper sense, implies an influence of the changes of the moon on the state of the mind or body, of which modern science cannot recognize the existence. It is true that many diseases are periodical in their returns, and it is not improbable that paroxysms of violence among insane persons may be really increased at the time of a full moon, by the effect of the shadows of clouds, and other objects, as ghosts are generally seen by moonlight; but any other lunar influence neither experience nor science can discover. The causes of insanity are divided, by modern writers, into physical and moral. Every excess of passion, joy, grief, anger, fear, anxiety, &c., becomes a moral cause of insanity.

Great political or civil revolutions have always been observed to be attended with numerous cases of mental derangement. Pinel observed this phenomenon in France, after the revolution of 1789; and Dr. Rush describes similar effects in the United States of America, after the war of the revolution. Strong religious excitement often produces similar results, although, in many cases, religious enthusiasm is only a form of the malady, and not a cause. Madden states that insanity is rare among the Mohammedans, and attributes it to their consoling belief in the certainty of their salvation. Dr. Rush thinks that the disease is more common among civilized communities than with savages, on account of the greater influence of moral causes on the former. The physical causes of insanity are various and numerous; diseases of various kinds and of different organs, bodily injuries or wounds, excessive indulgence in eating, drinking, and other sensual pleasures, privation, exposure to extreme cold or heat, &c., are among them. Insane persons are often, however, in good health, and dissection does not always detect a disordered condition of the organs. Philosophy is not sufficiently acquainted with the mutual action and re-action of the body and the mind on each other to decide how far the disordered state of the one is consistent with the sanity of the other; nor is it certain that there is any one organ or function which must be diseased to affect the mind.

Climate, age, occupation, and sex, are often mentioned as causes influencing insanity. But climate does not appear to be an exciting cause, although the moral, civil, religious, or physical condition of a nation may have rendered the disorder more frequent in some countries than in others. The seasons, however, appear to exercise an influence, and it is generally observed that the cases of insanity are most numerous in the hottest part of the year. Suicides are most frequent when the thermometer is above 84°.

Although many circumstances, both physical and moral, might seem to render the female sex most liable to insanity, it does not appear that the number of insane females is greater than that of males: drunkenness being more prevalent among the latter may be one cause of this. In both sexes, the most active period of life, from thirty to forty, presents the greatest number of cases. In regard to occupation, sufficient data do not exist to show that there is any decided predominance of cases in any particular employment. Idiocy is either a congenital or an acquired defect of the intellectual faculties, or, as Pinel defines it, an obliteration, more or less absolute, of the functions of the understanding and the affections of the heart. Congenital idiocy may originate from a malformation of the cranium, or of the brain itself; the senses are often wanting or defective, and life is commonly of short duration. Acquired idiocy proceeds from mechanical injury of the cranium, or from an injury or a disease of the brain, from excess in sensual indulgences, intemperance, fatigue, and from moral causes. In this, the senses may be par-

tially affected or quite destroyed, and life often continues to old age. Absolute idiocy admits of no cure; but it should not too hastily be concluded that a patient is in this state.

Mania is a species of mental derangement characterized by the disorder of one or several of the faculties, or by a blind impulse to acts of fury. Adults are the principal subjects. A nervous temperament, or an irritable constitution, predisposes to it. Females are more exposed to it than males, particularly at the period when menstruation begins or ceases, during pregnancy, and after delivery. Violent emotions, a dissipated life, excess in any indulgence, sometimes produce it. The disorder of the intellectual faculties is manifested by extravagant, gay, gloomy, or furious emotions; the gestures and words seem automatic. Sometimes the conversation is rational, but the patient bursts out at intervals into paroxysms of rage, attacking every thing which he meets; the moral affections also seem deadened, and the most ferocious hatred is displayed towards the most natural objects of love. It is sometimes cured, at other times remains stationary, and sometimes is converted into demency. Repeated bleeding, hellebore, cold water poured upon the head, scourging, and other means of terror were formerly employed as remedies. At present, solitude, warm baths, low diet, &c., are more commonly applied.

Melancholy, called also *monomanie;* a species of mental disorder, consisting in a depression of spirits. Some dark or mournful idea occupies the mind exclusively, so that, by degrees, it becomes unable to judge rightly of existing circumstances, and the faculties are disturbed in their functions. The powers of the soul become weakened, we might say crippled. If these feelings are allowed to attain a height at which the power of self-control is lost, a settled gloom takes possession of the mind. Consciousness, however, may still continue; the person knows his state. But if consciousness is also lost, if this state becomes continual, the melancholic patient is insensible to the world around him; he lives only within himself, and there only in the circle of one fixed idea. In this disordered state of the feelings, the other faculties may still continue to act, although the mode and result of their operation will necessarily be influenced by the existing disease. There may be reflection in the actions of the patient, but the reflection proceeds from false premises. Several kinds of melancholy are distinguished; the distinctions are founded, however, mostly on the cause of the disease. A very common cause of melancholy is love. He who loses the great object of his wishes and affections, which has absorbed, we might almost say, the whole activity of his soul, feels more than jealousy at the success of a fortunate rival; existence appears to him a blank, and himself the most unhappy of men. Another frequent cause of melancholy is gloomy views of religion. A constant excitement of the feelings by the awful picture of the eternal punishment of sin often produces absolute despair. The use of such means, to prepare the mind for the reception of deep religious principle, has not unfrequently led to distraction and suicide. Repeated failures in enterprises pursued with anxious zeal may also reduce the faculties of a man so much that he becomes wrapt up solely in the idea of his misfortune.

Melancholy patients often flee from men, haunt solitary places, such as grave-yards, and are given to nocturnal rambles. The course of the disease is various; sometimes it lasts a series of years; sometimes it ceases of itself, or is cured by medical aid; more frequently it passes over into other kinds of insanity, or into bodily diseases, as dropsy of the chest, consumption, dropsy in the head, apoplexy, &c. It is said that melancholy people rarely suffer from the gout or are attacked by epidemic diseases. Several physical causes are enumerated as inducing it, particularly a superfluity of black bile. Various derangements in the physical system tend to occasion it, as debility of the nerves, violent flow of the blood to the heart, superfluity of thick blood. Burton's *Anatomy of Melancholy* consists chiefly of extracts from ancients authors illustrating the causes, effects, and cure of that morbid affection. The author's own reflections are few, but they are original, ingenious, and striking. The subject of insanity is fully treated in the following works:—Burrow's *Commentaries on the Causes, Forms, Symptoms, and Treatment of Insanity* (London 1828); Pinel, *Traité sur l'Aliénation Mentale;* Voisin, *Des Causes Morales et Physiques des Maladies Mentales* (1826).

MEPHITIC is used to signify those kinds of air which will not support combustion or animal life, or, more generally, offensive exhalations of any sort. Modern chemistry has given particular names to many of these. (See CARBON and SULPHUR.)

MERCANTILE SYSTEM is one that prevails to a greater or less extent in every country of Europe. It was introduced into France by Colbert. As originally understood and acted upon, it embraces some fallacious doctrines, and carries some just ones to excess. The notion, for example, that wealth is derived mostly from foreign commerce, and depends upon an annual importation of specie, called the *balance of trade*, is erroneous. This balance was understood to be the bullion or coin received by a country in exchange for a part of its exports, and the foreign trade was supposed to be advantageous and promotive of the national wealth in proportion as the returns of trade were made in the precious metals, instead of other merchandise; whereas an exchange for iron, tin, leather, or any other useful merchantable commodity, is quite as advantageous as the importation of specie. It will depend upon the wants of the community whether the importation of one or another article will most promote the national wealth. It would be quite absurd, therefore, to attempt, by legislation, to force trade to yield a balance in specie. As far as this was a direct object of the commercial system, it was accordingly mistaken. If a nation needs other things more than specie, such prices will be offered as will induce their importation. But this notion of the importance of the balance of exports and imports is not without its truth in a certain respect. It is undoubtedly an evil for one nation to be constantly indebted to another. It will be found true between individuals, between different districts of the same country, and also between different nations, that the indebted party is the one most liable to make sacrifices. If a people or district, or an individual, will keep in advance of their means, and anticipate the income of the coming year, the consequence will be a perpetually straitened and embarrassed state. This was always the case with the British American colonies, and even of the United States for many years after the

establishment of American independence. The liberal credits in England enabled them to anticipate their income, and they were, accordingly, always largely indebted to this country, and thus constantly straitened and distressed, notwithstanding the country was during the same time rapidly growing in population and wealth. It is desirable that the commerce of a country should be so conducted as not to keep the country constantly indebted. If we were, therefore, to consider the balance of trade to be a constant standing balance of debt due to or from a country, in this sense it would be a subject of great importance. The consequence of large foreign credits, and of the desire to consume more of foreign products than the people have present produce of their labour sufficient to pay for, is occasionally to drive specie from the country; and the more extensive the credits the more complete and exhausting will be this drain when it happens.

MERCURY, or QUICKSILVER. The name *quicksilver* is derived from the alchemists, who regarded this metal as silver in a fluid state, quickened by some inherent principle, which they hoped either to fix or expel. It was known to the ancients, especially to the Greeks and Romans, who employed it in gilding and in the extraction of the precious metals. It is distinguished from all other metals by its extreme fusibility, which is such that it does not take the solid state until cooled to the thirty-ninth degree below 0 (Fahrenheit), and, of course, is always fluid in the temperate climates of the earth. Its colour is white, and rather bluer than that of silver. In the solid state it is imperfectly malleable; specific gravity, 13.6. It is volatile, and rises in small portions at the common temperature of the atmosphere. At the temperature of 656° it boils rapidly, and rises copiously in fumes. When exposed to such a heat as may cause it to rise quickly in the vaporous form, it gradually becomes converted into a red oxide, provided oxygen be present. This was formerly known by the name of *precipitate per se*. A greater heat than 600°, however, revives this metallic oxide, at the same time that the oxygen is again liberated, and we may thus procure a plentiful supply of oxygen gas for chemical experiments.

Mercury, if quite pure, is not tarnished in the cold by exposure to air and moisture; but, if it contains other metals, the amalgam of those metals oxidises readily, and collects as a film upon its surface. It is said to be oxidised by long agitation in a bottle half full of air, and the oxide so formed was called by Boerhaave *Ethiops per se;* but it is very probable that the oxidation of mercury observed under these circumstances was solely owing to the presence of other metals. The oxides of mercury are two. The *protoxide*, which is a black powder, insoluble in water, is best prepared by mixing calomel briskly in a mortar with pure potassa in excess, so as to effect its decomposition as rapidly as possible. The protoxide is then to be washed with cold water, and dried spontaneously in a dark place. The *peroxide*, which is commonly known under the name of *red precipitate*, is prepared, as already mentioned, from the combined agency of heat and air, or by dissolving mercury in nitric acid, and exposing the nitrate so formed to a temperature just sufficient to drive off the whole of the nitric acid. It contains double the quantity of oxygen found in the protoxide. It is acrid and poisonous, and carries these qualities into its saline combinations; whereas the protoxide is relatively bland, and is the basis of all the mild mercurial medicines.

Of the combustibles, mercury unites only with phosphorus and sulphur. The *phosphuret* is formed by heating either of the oxides along with phosphorus in a retort filled with hydrogen gas, or under water, with frequent agitation: the oxide is reduced, and a phosphuret is the result. It is of a black colour, is easily cut with a knife, and, in the air, exhales vapours of phosphorus. There are two sulphurets, the black and the red, or the *proto-sulphuret* and the *deuto-sulphuret*. The first is formed by rubbing vigorously in a glass or porcelain mortar three parts of sulphur and one of mercury, or by adding mercury at intervals, and with agitation, to its own weight of melted sulphur. The second, which is commonly called *cinnabar*, or *vermilion*, is formed by subliming the proto-sulphuret. Large quantities of it are manufactured in Holland. The ordinary process consists in binding together 150 lbs. of sulphur and 1080 of quicksilver, and then heating the mixture in a cast-iron pot, two feet and a half in diameter, and one foot deep, precautions being taken that the mixture does not take fire. The calcined Ethiops is then ground to powder, and introduced into pots capable of holding twenty-four ounces of water each, to which are attached subliming vessels, or bolt-heads of earthenware. The sublimation usually takes thirty-six hours, when the sublimers are taken out of the furnace, cooled, and broken.

The acids sustain an important relation to mercury. All of them either dissolve the metal or unite with its oxides. Sulphuric acid exerts little or no action upon it in the cold; but, if heat is applied, it is decomposed, the mercury is oxidated, sulphurous acid is disengaged, and the oxide combines with the remaining acid. This *proto-sulphate* of mercury crystallizes in slender prisms, forming a mass, soft, and partly liquid. It is very acrid, deliquescent, and soluble in water. If it is urged with a heat gradually raised until the mass becomes dry, the metal is more highly oxidated, and a portion of the acid is dissipated. On pouring boiling water on this dry mass, it acquires a lively yellow colour, forming an insoluble powder, known by the appellation of *turbith mineral*, or yellow sulphate of mercury. The water, in this process, produces the usual effect which it has when it decomposes metallic salts. Exerting a stronger attraction to the acid than to the metallic oxide, it combines principally with the former; but, from the influence of quantity on chemical affinity, the acid carries with it a portion of the oxide, and conversely, from the operation of the same force, the oxide which is precipitated retains a portion of the acid combined with it. The neutral sulphate is thus resolved into a super-sulphate, which the water dissolves, and a sub-sulphate, which remains undissolved. This sub-sulphate is chiefly used in preparing corrosive sublimate and calomel.

Nitric acid acts on mercury with facility, oxidating it, and combining with the oxide, forming a perfect solution. The product of this action varies considerably, particularly with regard to the state of oxidation, according to the circumstances under which it is exerted. If the acid is diluted with rather more than an equal part of water, and if the action is not accelerated by heat, the protoxide only

is formed, and the salt is the *proto-nitrate of mercury*. If the acid is less diluted, and if its action on the metal is promoted by heat, the peroxide is produced, and the compound is the *per-nitrate of mercury*. Both these solutions, when concentrated, crystallize, a mass being deposited, consisting of a congeries of slender prisms. Both salts are corrosive, deliquescent, and soluble in water. If the solution of the per-nitrate is poured into water, a partial decomposition happens, similar to that of sulphate of mercury, and a yellow insoluble sub-per-nitrate of mercury is precipitated.

Nitrate of mercury is decomposed by the alkalies and earths; and in these decompositions are well displayed the differences which arise from different states of oxidation of the metal. By potash, soda, or lime, added to the solution of the proto-nitrate, a precipitate of a grayish colour, with a tinge of yellow, is thrown down: from the solution of the per-nitrate the precipitate is yellow, more or less bright. These precipitates are sub-nitrates, the oxide, separated by the alkali, retaining a portion of the acid combined with it. The action of ammonia on these solutions is more peculiar. From the solution containing the mercury at a high state of oxidation, it throws down a white precipitate, which is a ternary combination of the oxide, with portions of the acid and alkali. From the solution at which the metal exists at the *minimum* of oxidation, it throws down a precipitate of a dark gray or blue colour.

A *fulminating* preparation of mercury is obtained by dissolving 100 grains in one and a half ounce by measure of nitric acid. This solution is poured cold into two ounces by measure of alcohol in a glass vessel, and heat is applied till effervescence is excited, though it ordinarily comes on at common temperatures. A white vapour undulates on the surface, and a powder is gradually precipitated, which is immediately to be collected on a filter, well washed, and cautiously dried. This powder detonates loudly by gentle heat or slight friction. It has been very much used of late as the match-powder, or priming, for the percussion caps of the detonating locks of fowling-pieces. Two grains and a half of it, mixed with one-sixth of that weight of gunpowder, form the quantity for one percussion cap, according to the researches of Aubert, Pelissier, and Gay-Lussac. In preparing this powder in quantities, the fulminating mercury should be moistened with thirty per cent. of water, then triturated in a mortar, and afterwards mingled with the sixth part of its weight of gunpowder. Matches of this kind resist damp very well, and take fire after several hours' immersion in water. The detonating match, or priming powder, made with chlorate of potash, sulphur, and charcoal, has the inconvenience of rusting and soiling the fowling-pieces, and thence causing them to miss fire; whereas, with the above fulminating powder, 100 shots may be discharged successively. The mercurial percussion caps are sold now in Paris for three francs and a half per thousand.

The acetic and most other acids combine with the oxide of mercury, and precipitate it from its solution in the nitric acid. Muriatic acid does not act on mercury. When mercury is heated in chlorine, it burns with a pale-red flame, and the substance called *corrosive sublimate* is formed. This *deuto-chloride* may also be formed by mixing together equal parts of dry bi-deuto-sulphate of mercury and common salt, and subliming. The corrosive sublimate rises, and incrusts the top of the vessel, in the form of a beautiful white semitransparent mass, composed of very small prismatic needles. Its specific gravity is 5.14. Its taste is acrid, stypto-metallic, and eminently disagreeable. It is a deadly poison. Twenty parts of cold water dissolve it, and less than one of boiling water. It is composed of 73.53 mercury and 26.47 chlorine. It may be recognized by the following characters:—It volatilizes in white fumes, which seem to tarnish a bright copper-plate, but really communicate a coating of metallic mercury, which appears glossy white on friction. When caustic potash is made to act on it with heat in a glass tube, a red colour appears, which by gentle ignition vanishes, and metallic mercury is then found to line the upper part of the tube in minute globules.

Solution of corrosive sublimate reddens litmus paper, but changes syrup of violets to green. Bicarbonate of potash throws down from it a deep brick-red precipitate, from which metallic mercury may be procured, by heating it in a tube. Lime-water causes a deep yellow precipitate, verging on red. Water of ammonia forms a white precipitate, which becomes yellow on being heated. With sulphureted hydrogen and hydrosulphurets, a black or blackish-brown precipitate appears. Nitrate of silver throws down the curdy precipitate characteristic of muriatic acid; and the proto-muriate often gives a white precipitate. From six to twelve grains were the mortal doses employed by Orfila, in his experiments on dogs: they died in horrible convulsions, generally in two hours; but when, with a larger quantity, the whites of eight eggs were thrown into the stomach, the animals soon recovered after vomiting. The effect of this antidote is to convert the corrosive sublimate into calomel. Sulphureted hydrogen may also be employed along with emetics. The *proto-chloride* of mercury (*mercurius dulcis*, or *calomel*), is usually formed from the deuto-chloride, by triturating four parts of the latter with three of quicksilver till the globules disappear, and subjecting the mixture to a subliming heat. By levigating and edulcorating with warm water the sublimed grayish-white cake, the portion of soluble corrosive sublimate which had escaped decomposition is removed. It may also be made by adding solution of proto-nitrate of mercury to solution of common salt; the proto-chloride, or calomel, precipitates. The following is the process used at Apothecaries' Hall:—Fifty pounds of mercury are boiled with seventy pounds of sulphuric acid to dryness, in a cast-iron vessel; sixty-two pounds of the dry salt are triturated with forty pounds and a half of mercury until the globules disappear, and thirty-four pounds of common salt are then added. This mixture is submitted to heat in earthen vessels, and from 95 to 100 lbs. of calomel are the result. It is washed in large quantities of distilled water, after having been ground to a fine and impalpable powder. When proto-chloride of mercury is very slowly sublimed, four-sided prisms terminated by prisms, are obtained. It is nearly tasteless and insoluble, and is purgative in doses of five or six grains. Its specific gravity is 7.176. Exposure to air darkens its surface. It is not so volatile as the deuto-chloride.

Nitric acid dissolves calomel, converting it into corrosive sublimate. Proto-chloride of mercury is composed of mercury 84.746, and chlorine 15.254. There are two *iodides* of mercury; the one yellow, the

other red; both are fusible and volatile. The yellow, or *protiodide*, contains one half less iodine than the deutiodide; the latter, when crystallized, is a bright crimson. They are both decomposed by concentrated sulphuric and nitric acids. The metal is converted into an oxide, and iodine is disengaged. They are likewise decomposed by oxygen, at a red heat.—Mercury, on account of its fluidity, readily combines with most of the metals, to which it communicates more or less of its fusibility. When these metallic mixtures contain a sufficient quantity of mercury to render them soft at a mean temperature, they are called *amalgams*. It very readily combines with gold, silver, lead, tin, bismuth, and zinc; more difficultly with copper, arsenic, and antimony; and scarcely at all with platina or iron. It does not unite with nickel, manganese, or cobalt; and its action on tungsten and molybdena is not known. Looking-glasses are covered on the back side with an amalgam of tin. The amalgamation of the precious metals, water gilding, the making of vermilion, the silvering of looking-glasses, the construction of barometers and thermometers, are the principal uses to which this metal is applied. Scarcely any substance is so liable to adulteration as mercury, owing to its property of dissolving completely some of the baser metals. This union is so strong that they even rise along with it in vapour when distilled. Its impurity, however, can generally be detected by its dull aspect; by its tarnishing, and becoming covered with a coat of oxide, on long exposure to the air; by its adhesion to the surface of glass; and, when shaken with water in a bottle, by the speedy formation of a black powder. Lead and tin are frequent impurities, and the mercury becomes capable of taking up more of these, if zinc or bismuth be previously added. In order to discover lead, the mercury may be agitated with a little water, in order to oxidize that metal: pour off the water, and digest the mercury with a little acetic acid; this will dissolve the oxide of lead, which will be indicated by a blackish precipitate, with sulphureted water; or to this acetic solution add a little sulphate of soda, which will precipitate a sulphate of lead, containing, when dry, seventy per cent. of metal. Bismuth is detected by pouring a nitric solution, prepared without heat, into distilled water; a white precipitate will appear, if this metal be present. Tin is manifested, in like manner, by a weak solution of proto-muriate of gold, which throws down a purple sediment; and zinc by exposing the metal to heat.

The medicinal virtues of this mineral were almost totally unknown to the ancients, who considered it as a poison. It was first employed for purposes of medicine by the Arabians, who made use of it in the form of ointments for the skin and the killing of vermin. In modern times mercury is one of the most important articles of the materia medica. It has an advantage over all others in being a specific remedy for a disease which tends more than any other to the destruction of the human species, and which, without this inestimable discovery, would probably have continued incurable to the present day.

Mercury, taken into the stomach in its metallic state, has no action on the body, except what arises from its weight or bulk. It is not poisonous as is vulgarly supposed, but perfectly inert. But, in its various states of combination, it produces certain sensible effects. It quickens the circulation, and increases all the secretions and excretions.

The metallic oxide of mercury differs very much in its effects on the system. Sometimes, it more particularly increases one secretion; sometimes another; but, its most characteristic effect is the increased flow of saliva, which it generally excites, if given in sufficient quantity.

Mercury; the finest plant in order from the sun. (See Astronomy.)

Meridian, in *astronomy*, is a great circle of the celestial sphere, passing through the pole of the earth and the zenith and nadir, crossing the equator at right angles, and dividing the sphere into an eastern and western hemisphere. When the sun is on this circle, it is noon or mid-day to all places situated under that meridian.

Meridian, in *geography;* a corresponding terrestrial circle in the plane of the former, and which, therefore, passes through the poles of the earth. All places situated under the same meridian have their noon or midnight at the same time; but, under different meridians, it will arrive sooner or later, according as they are situated to the eastward or westward of each other; viz. the sun will be upon that meridian soonest which is most to the eastward, and that at the rate of an hour for every 15°.

First Meridian is that from which all the others are reckoned, which, being totally arbitrary, has been variously chosen by different geographers. Ptolemy makes his first meridian pass through the most western of the Canary Islands; others have chosen Cape Verd; some the Peak of Teneriffe; others the Island of Ferro, &c.; but most nations now consider that the first meridian which passes over their metropolis, or their principal observatory. Thus we reckon from the meridian of Greenwich; the French from Paris; the Spanish from Madrid; the Americans from Washington, &c.

Meridian of a Globe is the brazen circle in which it turns, and by which it is supported. *The brazen meridian* is divided into 360 equal parts, called *degrees*. In the upper semicircle of the brass meridian these degrees are numbered from 0 to 90, or from the equator towards the poles, and are used for finding the latitudes of places. On the lower semicircle of the brass meridian they are numbered from 0 to 90, from the poles towards the equator, and are used in the elevation of the poles.

Meridian Line is a line running due north and south, the exact determination of which is of the greatest importance in all cases relating to astronomy, geography, dialling, &c., because on this all the other parts have their dependence. The most celebrated meridian line is that on the pavement of the church of St. Petronio, in Bologna, which was drawn to the length of 120 feet, by the celebrated Cassini. Without knowing the meridian line of a place, it would be impossible to make a dial, set a clock, or measure degrees on the earth's surface.

Meridian Line, on a dial, is the same as the twelve o'clock hour line.

Magnetic Meridian; a great circle passing through the magnetic poles. (See Magnetism.)

Meridian Altitude; the altitude of any of the heavenly bodies when they are upon the meridian.

Merlon, in *fortification*, is that part of a parapet which is terminated by two embrasures of a battery. Its height and thickness are the same with that of the parapet; but its breadth is generally nine feet on the

inside, and six on the outside. It serves to cover those on the battery from the enemy; and it is better when made of earth, well beat and close, than when built with stones, because they fly about and wound those they should defend.

MESENTERY; a membrane in the cavity of the abdomen, attached to the lumbar *vertebræ*, and to which the intestines adhere. Its uses are to sustain the intestines in such a manner that they may possess both mobility and firmness to support and conduct the blood-vessels, lacteals, and nerves, to fix the glands, and give an external coat to the intestines.

MESS, in *sea* language, denotes a particular company of the officers or crew of a ship, who eat, drink, and associate together, whence *messmate*, one of the number thus associated. In military language, *mess* denotes a sort of military ordinary, for the maintenance of which every officer who takes his meals there gives a certain proportion of his pay. These associations of officers in the English armies exist not merely in time of peace, but even in the field; and foreigners are surprised at the degree to which the national love of comfort prevails, even amid the fatigues of service, leading the officers to carry with them loads of table equipage, thereby adding to the cumbrous baggage of an English army. In all the descriptions of English military life the mess is conspicuous; and it may easily be imagined that these social meetings, when the toils of service are suspended, and the pleasures of the table are heightened by music—when the restraints of military etiquette are relaxed, and a soldier-like frankness prevails—when the young express their hopes, and the older relate their experiences—are among the bright spots of British military life. Several armies, particularly the Prussian, have attempted in time of peace to imitate the English mess, but without being able to copy it fully.

MESTRE DE CAMP; formerly the title of the commanding officer of a regiment of cavalry in the French service. He was distinguished by this appellation on account of there being a colonel-general in the cavalry. The chief of a regiment of infantry was also formerly so called.

METAL; the most numerous class of undecompounded chemical bodies, distinguished by the following general characters:—1. They possess a peculiar lustre, which continues to be seen in the smallest fragments. 2. They are fusible by heat, and in fusion retain their lustre and opacity. 3. They are all (except selenium) good conductors both of electricity and caloric. 4. Many of them may be extended under the hammer, and are called *malleable*; or under the rolling-press, and are called *laminable*; or drawn into wire, and are called *ductile*. 5. When their saline combinations are electrized, the metals separate at the negative pole. 6. When exposed to the action of oxygen, chlorine, or iodine, at an elevated temperature, they generally take fire, and, combining with one or other of these three elementary dissolvents, in definite proportions, are converted into earthy or saline-looking bodies, devoid of metallic lustre and ductility, called *oxides*, *chlorides*, or *iodides*. 7. They are capable of combining in their melted state with each other, in almost every proportion, constituting alloys. 8. Most of them combine in definite proportions with sulphur and phosphorus, forming bodies frequently of a semi-metallic lustre; and others unite with hydrogen, carbon, and boron, giving rise to peculiar gaseous or solid compounds. Their names are as follows:—1. platinum, 2. gold, 3. silver, 4. palladium, 5. mercury, 6. copper, 7. iron, 8. tin, 9. lead, 10. nickel, 11. cadmium, 12. zinc, 13. bismuth, 14. antimony, 15. manganese, 16. cobalt, 17. tellurium, 18. arsenic, 19. chromium, 20. molybdenum, 21. tungsten, 22. columbium, 23. selenium, 24. osmium, 25. rhodium, 26. iridium, 27. uranium, 28. titanium, 29. cerium, 30. potassium, 31. sodium, 32. lithium, 33. calcium, 34. barium, 35. strontium, 36. magnesium, 37. yttrium, 38. glucinum, 39. aluminum, 40. zirconium, 41. silicium, 42 thorinum, 43 vanadium. The first twelve are malleable, and so are the 30th, 31st, and 32nd, in their congealed state. The first sixteen yield oxides, which are neutral salifiable bases. The metals 17, 18, 19, 20, 21, 22, and 23 are acidifiable by combination with oxygen. Of the oxides of the rest, up to the 30th, little is known. The remaining metals form, with oxygen, the alkaline and earthy bases.

A very curious test of the state of metals has lately been brought before the scientific world, which must be noticed in the present place. It is well known that Dr. Wollaston devised a beautiful little arrangement to ascertain the conducting power of certain crystals having metallic characters, and which, ultimately, proved to be titanium. If a plate of copper be in contact with a plate of zinc, and part of both plates be immersed in a dilute acid, the copper, by its electric condition, decomposes water, and becomes covered with bubbles of hydrogen. If a piece of paper or a card be interposed where the two metals were in contact, the copper loses this power altogether, and no bubbles appear on it; but if a small hole be made in the paper or card, and a little piece of metallic matter put there so as to touch at once both the zinc and copper, then the latter has its full power restored. M. Macaire Prinsep has applied this test more generally; and he found, in the first place, that a metal was necessary to restore the effect; lead, bismuth, tin, &c., re-produced the bubbles; but sulphuret of arsenic, rutulite, or oxide of titanium, gray cobalt ore, and the sulphuret of antimony, iron, tin, or lead, produced no effect. Portions of meteoric stone from Aigle and Barbosan, by producing bubbles, showed that they contained uncombined metal; and the method seemed competent to indicate, in all cases, whether the metals were free or in a combined condition.

As lead gave bubbles, but the sulphuret of lead none, experiments were made with lead, to which sulphur, in increasing proportions, had been added. 1-100th, 1-50th, 1-32d, 1-16th, and 1-12th of sulphur did not take away the property from lead, but when 1-8th of sulphur was used no bubbles appeared upon the copper; then, ascertaining the proportions in the definite sulphuret of lead, he found them to be exactly those which caused the evolution of bubbles to cease (eighty-six lead and fourteen sulphur). The same effect occurred with the sulphuret of tin; and hence it was concluded that chemical combination, in determinate proportions, was necessary to prevent this electric decomposition, and that mixtures had no influence on the phenomena.

METALLOID, in *chemistry*; a name given at first to the metals which have been obtained from the fixed alkalies and some of the earths. These bodies having been found to be completely metallic are now classed with the other metals, and no distinction is necessary.

METALLURGY, METALLURGIC CHEMISTRY, is that

part of chemistry which teaches the combinations and analyses of metals. It has been much cultivated of late.

Meteorology; that science which investigates the phenomena of our atmosphere (commonly called *meteors*), giving an account of the circumstances attending each, and explaining the causes from which they arise.

In considering this science, we find the objects of it naturally divided into two classes, viz. those which rise high in the heavens, seemingly without any connection with this earth; and others which are more particularly connected with the earth, or are perceptible only in the lower regions of the atmosphere. The former, which may properly be called *celestial meteors*, are only three in number, viz. the large fire-balls, falling stars, and aurora borealis. The second class is much more numerous, including the phenomena of the ordinary winds, rain, hail, snow, clouds, and vapours of all kinds, thunder and lightning, hurricanes, whirlwinds, water-spouts, ignes fatui, and other wandering luminous appearances, not excepting the various changes of the atmosphere itself, with regard to its specific gravity, rarefaction, heat, and moisture, as indicated by the barometer, thermometer, and hygrometer.

To treat of all these in a satisfactory manner, it is plain that we ought to have an intimate acquaintance with the constitution of the atmosphere, with the nature of those powerful agents by which it appears to be principally influenced, viz. fire, light, and electric fluid, and with their peculiar modes of operation and action upon one another and upon the atmosphere, and this in every possible variety of circumstances. Nor is even all this sufficient: the various phenomena of rain, wind, snow, thunder, heat, cold, &c., are known to depend very much upon the situation of different places on the surface of the earth; and their occasional variations are with great reason *suspected* to proceed, partly at least, from changes which take place in the bowels of the earth: whence a meteorologist ought not only to be perfectly well acquainted with geography, but with mineralogy chemistry, the analysis of metals, and the general principles of natural philosophy.

In a science so very difficult, it is not to be supposed that any thing like a certain and established theory can be laid down: our utmost knowledge in this respect goes no further as yet than to the establishment of a few facts; and, in reasoning even from these, we are involved every moment in questions which seem scarcely within the compass of human wisdom to resolve.

In considering the subject of meteorology, it will readily be admitted that the whole atmospherical phenomena depend, some how or other, upon the action of the sun upon the earth, and the annual and diurnal revolutions of the latter. As these causes, however, are always invariably the same, why do we not find the same regularity in meteors that we do in other phenomena of nature? The eclipses of the sun and moon, for instance, which depend on the different positions of the earth and moon with regard to the great luminary, are found to follow a certain and regular course; so that the very same eclipses both as to quantity and duration, which happened before will happen again. But with meteors the case is quite different. Most of the atmospherical phenomena are so various and uncertain that no person can pretend to reduce them to any kind of rule. Every succeeding year, for instance, differs in a vast number of particulars from that which preceded it, even in such as are the most similar to one another. Sometimes we find a number of years successively similar to one another, and another set quite different taking place immediately after them; and some have even fancied that this succession took place every nineteen years, nearly the time of the revolution of the moon's nodes, though the observations on which this opinion is built are far from being sufficient to establish it: at any rate, the dissimilarity between the phenomena of different years may sufficiently warrant us to conclude that other causes besides the regular action of the sun and revolution of the earth are concerned. Some of these causes may be supposed to be chemical changes and other commotions within the bowels of the earth itself; but as all chemical change is a regular process, and takes place only in certain circumstances, of which heat is a very considerable one, why is there not annually a certain quantity of this fermentation excited, and why are not regular effects observed in proportion? It does not, indeed, appear that the immense variety which occurs in meteorological appearances can by any means be accounted for but by the interference of some causes in their own nature *irregular*; that is, capable of such endless variety that no assignable space of time is sufficient to exhaust it. These causes, as they cannot be proved to exist either on the surface of the earth or in its internal parts, must be sought for in the celestial expanse itself. Sir Isaac Newton supposed the planets to be influenced by the comets, and that from the tails of the latter some of the finer parts of our atmosphere were produced. He even supposed that from these bodies a quantity of water, imagined to be wasted in the various operations of nature, might be supplied. But, if it is not unreasonable to suppose that *comets* answer some such purposes in nature, it is as little unreasonable to think that the *planets* may influence the atmospheres of one another. That this must be the case indeed is very probable, not only on account of the light they reflect upon one another, but also by reason of their spheres of mutual attraction, which extend an immense way, and are so powerful in the planets Jupiter and Saturn that they disturb the motions of each other's satellites as they pass. But, besides even these causes, if we allow them to be such, there are others which take place in the immense void betwixt the celestial bodies, and which has with great impropriety been determined an absolute vacuum. That changes do take place in this space is evident from what is related of the temporary disappearance of some of the satellites of Saturn, and their sudden re-appearance, without any perceptible change in our atmosphere so as to affect our view of other celestial objects. It may appear ridiculous to think that a change in such distant regions should have any influence upon the atmosphere of the earth; but we must remember that if the universe is connected together as one vast system, which we have every reason to believe it is, as impossible that a change can take place in any part without affecting the whole in some degree as it is impossible to change any part of a clock or watch without in some measure affecting the whole movement.

But, of all the changes which take place in the

celestial regions, those which affect the sun seem most likely to produce changes in our atmosphere, and to be the hidden cause of many meteorological phenomena. That the sun is not exempt from those changes is evident from the spots which are always, or for the most part, to be seen on his disc when viewed through a telescope. It has been observed in some years that the sun has seemed to lose his influence, and even to the naked eye appeared much dimmer than usual. In such cases it is impossible but our atmosphere, and even the whole solar system, must have been affected; and not only must the seasons for the present time have felt the malign influence of those spots, but the atmosphere itself may have acquired such a disposition as to produce seasons of a peculiar nature for a number of years afterwards. If it be true, according to the hypothesis of some, that the sun is supplied with fuel by comets falling into his body, it is plain that every new accession of this kind must have a proportionable effect upon all the bodies exposed to his light. If the comets do not perform any such office, still it is very probable that they answer some such purpose to the planets, as they are never seen beyond the planetary regions; and, though their influence be not immediately perceptible, it is impossible to prove that they have none, nor indeed is it probable that they have not; for we are very certain that the influence of any object extends as far as its light, and how much further we cannot tell. Considering the matter in this view, therefore, there is not a spot which can obscure the sun, a comet that can appear in the celestial regions, a planet that can approach the earth, nor, perhaps, a belt or spot which can take place on Mars, Jupiter, or Saturn, which may not be productive of important changes in our atmosphere, and affect the meteors produced by it in many different ways.

It would no doubt be an error to have recourse to so many obscure causes, were there any plain and obvious ones from which the phenomena could be deduced. But the endless variety of meteors which occur throughout every part of the globe plainly show that the causes, whatever they are, must be infinitely varied also. The principal one is no doubt the action of the sun upon the earth and atmosphere in its various positions; but this is regular, and, did nothing else interfere, would produce regular effects. Secondary causes probably are the action of the moon and planets; but these also are regular, though much more diversified than the former; so that we are at last obliged to have recourse to causes still more obscure and remote, as comets, spots on the sun, and changes taking place in the effects of those rays which pervade the whole celestial expanse. These we must either assign as the remote causes of the phenomena of our atmosphere, or admit others equally obscure, or we must be contented to own our ignorance, as, indeed, must at all events be frequently the case.

But though, to satisfy ourselves, such conjectures may occasionally be indulged, it is not from them that we are to derive any knowledge of the regular phenomena of nature; for these are evidently owing to the settled and established action of heat, light, and electric matter, which have already been enumerated as the great powers influencing and indeed in a great measure forming the substance of our atmosphere. The most remarkable effects of these are—

1. *Evaporation*. This, which is the principal cause of almost all the meteors of our atmosphere, may be reckoned in a more particular manner the effect of heat. Upon this principle vapour is shown to be a compound of water and fire; and such it is supposed to be by M. de Luc, in his *Treatise on Meteorology*, as well as by other philosophers of the highest rank. In considering this operation, however, as carried on by nature, we shall soon find that it proceeds in a manner very different from what takes place in our chemical operations. In the latter, evaporation is merely the effect of heat, and the process cannot go on without a considerable degree of it, especially if the vessel containing the fluid be close. In the natural way, on the contrary, the process goes on under almost every degree of cold we know; the vapours ascend to a height which has never yet been determined, and, from the extreme cold which they sustain, show evidently that they are connected with our atmosphere by means of some other agent besides heat. From the continual ascent of vapour, indeed, if the operations of nature were of the same kind with those of art, the upper parts of our atmosphere would be always involved in a fog, by reason of the condensation of the vast quantity which continually ascends thither; but so far is this from being the case that in those elevated regions to which the vapours continually ascend the air is much drier than at the surface of the ground. This was experienced by M. de Saussure and M. de Luc in their journeys up the Alps. The air was there found to be excessively dry, and evaporation to go on much more rapidly than below; so that the surface of their bodies was parched up, and an excessive thirst took place by reason of the great absorption of the moisture. The same dryness was manifested by the hygrometer, which could scarcely ever be brought to indicate any moisture, even when our travellers were surrounded with clouds, hail, and rain. From many experiments, indeed, it is evident that water, after being reduced into a state of vapour, is capable of undergoing a certain change, by which it partially lays aside its fluidity, and even, to appearance, its specific gravity; so that it becomes, as far as regards its mechanical character, totally different from what it was before. This may be familiarly understood from the common operation of slaking lime; for in that case the water unites with the lime so intimately that the whole assumes the form of a dry powder, extremely greedy of moisture, and which cannot be reduced to its former state of quicklime without undergoing a much greater degree of heat than the water by itself could bear. The same thing is manifest from mixing dry plaster of Paris with water; for thus a vast quantity of the water is fixed, and becomes in a manner solid. A still more remarkable instance is in sending the steam of water over red-hot iron; for there the oxygen of the water unites in such a manner with the metal that the other element, hydrogen, is entirely liberated. Here we are to consider the changes which the element undergoes after being reduced to the state of vapour. The first of these is its assuming the appearance of smoke or fog when mixed with the common atmosphere, which smoke, when examined by a very powerful microscope, appears to be composed of an infinite number of spherules of water. They are no doubt expanded by heat, and thus rendered lighter than air, by which means they ascend in it. As long

as the aqueous vapour retains this visible form, it retains also its humidity, and will again become a liquid, and wet whatever comes in its way; and this the more readily, while it retains any sensible degree of heat. As the vapour cools in the atmosphere, it gradually assumes an aërial state, mixing itself with the air, so as to be no longer distinguishable from it. In this state the air itself does not by any means appear to become more moist, but continually drier the more water it receives. This, however paradoxical it may seem, is a certain fact; for in summer, though we are assured that evaporation goes on very rapidly from the surface both of the sea and land, yet the air, so far from being moist, is much drier than at any other time; and yet we know that the whole quantity evaporated is, some how or other, received by the atmosphere. After the water has attained to this state, our enquiries concerning it must assume a new course.

On this subject M. de Luc has some very curious observations, built principally upon the chemical character of water, which was then first developed. As this gentleman is still considered as a good authority in matters of fact, we may embody his statements as nearly as possible in his own words. Our author first began to alter his sentiments concerning the *aqueous* existence of vapour in the atmosphere from the circumstance already mentioned concerning the great *dryness* of the upper atmospherical regions already taken notice of. A very remarkable instance of this was that the ferule of his cane dropped off during his journey up one of the Alpine mountains, which he never had observed it to do before. It is observed, likewise, that the air in these elevated regions is somewhat drier in the night than in the day-time; for which M. de Luc gives the following reason, viz. that the air on the plains being condensed by the cold, the superior air must subside, and the air on the mountains of course be replaced by the drier air from above them; though he thinks that this dryness may also be imputed in part to some other cause. This increase of dryness in the night, however, seems less constant than that in the day-time. Our author has often arrived at the tops of mountains before sunrise, and sometimes found the grass covered with dew, though he never had the good fortune to be able to determine the state of the air, for want of an hygrometer: nor, indeed, could the appearance of dew be any certain indication of the state of the atmosphere, there being strong reasons to believe that dew is occasioned, in a great measure, by vegetables themselves; for grass, when covered with glass plates, was found to become moist as well as that which had been exposed to the open air. In this case the plates became moist both on the upper and under sides; but when suspended a foot above the ground, they were found to be covered with dew only on the upper part.

The dryness of the air on the tops of high mountains was otherwise accounted for by M. Saussure.—When on Mont Blanc, at the height of 7200 feet above the level of the sea, he found that from six in the evening till half-past five next morning his hygrometer moved twenty-one degrees (the whole scale containing one hundred) towards dryness. But this he accounts for by saying that from sunrise to three or four in the afternoon, the quantity of vapours in the neighbourhood of the earth is continually diminishing, because they *ascend* in the atmosphere, either in virtue of their own levity, or by means of a vertical wind, which he supposes to be produced by the heat of the sun; that, from the time just mentioned till next morning, their quantity increases in the lower strata, because the upper vapours re-descend in proportion as they condense; and that in the higher regions of the atmosphere the reverse ought to be the case, as the upper strata are then left drier by the previous descent of the vapours. This argument, however, is contradicted by M. Saussure himself in another part of his work, where he says that in the middle of the day, when the sun is hottest, the air in the neighbourhood of the earth contains really more *water* than it does at the moment when a refreshing dew falls. It is besides impossible that a *vertical* wind can ever be occasioned by the heat of the sun; for this produces only a general expansion of the whole body of the atmosphere, as a condensation of it is occasioned by the action of cold, neither could any considerable quantity of vapour (supposing with M. Saussure that it is a chemical solution of water in air) descend in the night-time; for, according to him, this compound differs very little from common air in its capacity of being expanded and condensed. Neither, according to M. Saussure himself, can any part of the water with which the air is combined descend at all, until some portion of the former becomes supersaturated with it, that is, till it has received more than it can hold in solution. But, if this should happen to be the case, the superfluous quantity would then appear in the form of a mist or cloud, and the hygrometer would indicate extreme humidity; whereas the contrary indication constitutes the difficulty.

It is besides evident, from innumerable instances, that mere cold will not by any means occasion the condensation of aërial vapour. A most remarkable example of this is given by M. de Luc, in an account of a storm in which he was involved on one of the Alps. "Though the hygrometer (says he) was within 33½ degrees of extreme dryness, or 66½ from extreme humidity, thick clouds formed around us, which obliged us to think of retreating; in a little time the summit of the mountain was surrounded by them: they spread and covered the whole horizon: a premature night surprised us in a very dangerous road; and we suffered one of the most violent tempests I ever experienced of wind, rain, hail, and thunder. The storm lasted great part of the night, and extended all over the neighbouring mountains and plains; and after it had ceased the rain continued, with only a few intermissions, till next day at noon. In one of these intervals I examined the hygrometer on the outside of our cabin; it showed only $1\frac{8}{10}$ degrees more humidity than before; and even this increase was no more than what the difference of heat was capable of producing. Nevertheless, new clouds continually rolled around us; and the rain, which presently began again, accompanied us as it were by fits to the bottom of the mountain. When arrived there, we saw the clouds disperse entirely. I observed the hygrometer again in the open air; and though the earth was all drenched with water, and the heat of the sun much less, the hygrometer was $1\frac{7}{10}$ degrees drier than it had been two days before, after a course of fine weather. Where was all this water, and all the ingredients of the storm, while the hygrometer showed such a degree of dryness in the very stratum where it was formed?"

M. de Luc considers vapour as a combination of

fire with water. By *vapour*, however, he does not mean "the visible steam issuing from heated liquids, but that invisible and subtile fluid which is found to be formed even *in vacuo*, and which," he adds, "disproves the hypothesis of those who hold that vapour is a solution of water in air." Our author, however, gives a solution of the difference betwixt what he calls *fog* or *mist* and vapour which seems scarcely founded upon any evident principle. According to him, this vapour cannot subsist unless the particles of water united to the fire be at a certain distance from one another. When this distance is lessened a decomposition takes place, by reason of the attraction of the aqueous particles to one another; and they then appear in their proper form of a liquid, the fire dissipating itself through the atmosphere. The smallest distance to which the particles can be brought without any decomposition varies according to the temperature, but is always constant in the same degree. When the thermometer stands at temperate or thereabouts, watery vapours, compressed into the smallest space they can bear, are found to have between $\frac{1}{18}$th and $\frac{1}{38}$th of the elasticity of air; but have less than $\frac{1}{135}$th of its weight. If such vapour, however, be mixed with air, the minimum distance is greatly increased, by reason of the interposition of aërial particles; and thus it can subsist under a much greater pressure than it could otherwise endure. In the heat of boiling water it can, without any mixture of air, bear the pressure of the atmosphere; for ebullition, under any given pressure, cannot take place until the vapour produced in the liquor has acquired a degree of expansive force sufficient to raise the liquor into bubbles under that pressure; and as long as the vapour retains this heat it must continue capable of resisting the same pressure. As the heat abates, a decomposition begins; hence the opaque steam over boiling water, which, by becoming vapour again by uniting with the fire it meets within a larger space, is diffused by its expansibility. Thus vapours are continually undergoing decompositions and new vaporifications. This evaporation of the clouds after they were once formed M. de Luc states he observed very evidently, some parts being continually detached and gradually diminishing and disappearing, while new ones are formed; so that the clouds do not continue the same for two moments together, and the evaporation goes on so fast that a cloud could not subsist without constant and large supplies.—"These phenomena appear to be independent of heat and cold; for sometimes clouds form suddenly in the middle of a hot day, and after they have poured down their water all is clear again, and sometimes they evaporate after sunset, gradually vanishing in the calmest weather without any change of place.—The appearances are such as would be produced by a large mass of water in violent ebullition, suspended invisibly in the atmosphere; and the similarity of effect naturally points out an analogy in the cause; that is, a source of vapour in the atmosphere itself. It is only when the vapour is produced too abundantly and too rapidly to be dispersed by evaporation that rain is formed, the vesicles in this case running together, and the water falling to the lower part, as it does in soap-bubbles, till they become thin enough to burst."

Heat and cold are very powerful agents in producing various meteors; but these are only relative and different modifications of the same principle. Though we do not know what connexion there is between heat, cold, and what we call electricity, yet we know that this last is very much affected by them; for heat makes bodies more pervious to electricity than otherwise they would be, and cold makes them less so. Hence the most violent electrical phenomena are observed in hot countries; while in the colder regions those which depend on a more moderate electrification, as auroræ boreales, are more frequent. The prevalence of heat and cold in particular places, however, depends upon circumstances which are altogether unknown to us, and therefore we cannot investigate the modes of their operation in such a particular manner as could be wished. From what has been already said, however, respecting the nature of the different agents concerned in meteorology, both in this article and in other parts of the work, we may take the following view of the causes of meteors in general:—

1. Evaporation, combined with electricity, produces all the phenomena of vapour, fog, clouds, rain, &c.; and according as these two are joined to certain degrees of heat or cold they produce dew, hoar-frost, rain, hail, or snow.

The phenomena of dew and hoar-frost seem to proceed from a quantity of aqueous vapour which always exists in the atmosphere, and which, being raised by mere heat, is condensed by mere cold, without undergoing any other process. Hence it both ascends and descends; for, if we cover a small space of ground with plates of glass, they will be wetted both above and below. The reason of this is, that the evaporation from the ground does not stop immediately after the air begins to cool, especially if it be covered with any thing which prevents the access of the cold air, as the glass plates do in this case. The cold air, therefore, acting upon the glass, condenses the vapour below it in the same manner that the head of a still or the receiver of a retort condenses the vapours which rise from the matter to be distilled. If the cold be very intense, hoar-frost appears instead of dew, which is nothing more than the dew frozen after it falls upon the ground, in the same manner that the vapour in a warm room congeals on the inside of the windows in a frosty night. As this seems to be the whole process, it has not been observed that any electricity is concerned in the production of dew.

When the vapour has been thoroughly decomposed, and become invisible, it very frequently returns back to its pristine state, so far as to assume the appearance of mist or fog. In this case, electricity appears evidently to be concerned; for Mr. Cavallo observed that all fogs were electrified. When the process has advanced further, and the water begins to collect into drops, the electricity is still more remarkable; and it is by some supposed that it is by means of electrical repulsion that the drops of rain keep at a regular distance from one another. When the cold is intense, and the electricity strong, the drops of water are frozen, and hail is produced: but snow indicates a more moderate degree of electricity; and a very violent cold, accompanied with a strongly electrical atmosphere, produces that excessively disagreeable vapour in the polar regions called *frost-smoke*, which is a general congelation of all the aqueous moisture contained in the atmosphere.

2. By highly excited electricity alone are produced the phenomena of thunder, lightning, fire-balls, ignes fatui, and the aurora borealis. In the phenomena of

lightning, evaporation and the other agents by which rain and hail are produced are also concerned; though temperature is most remarkably so, and thunder and lightning frequently occur without any rain. The aurora borealis, large fire-balls, and the smaller ones called *falling-stars*, seem to depend upon a change in the electrical equilibrium alone, without any aid from evaporation. The aurora borealis, indeed, is most common in the northern and southern parts of the world, where the cold is intense, though this seems to be owing, not to the cold, but to the natural emission of the electrical fluid from the polar regions in much greater quantities than from others. The fire-balls commonly appear collected on the very extreme boundaries of the atmosphere. The ignis fatuus sometimes arises from the strong electricity of a certain portion of atmosphere, and at other times from the emission of gas.

3. By the action of heat and electricity combined are produced the phenomena of hurricanes, whirlwinds, and water-spouts. It is not, indeed, known in what manner those agents combine themselves to produce such tremendous effects; but it seems evident that electricity is concerned in them, as the sea-water becomes unusually clear before a hurricane, and many signs of electricity are usually observed in the heavens.

4. The winds are supposed to proceed mostly from the heat of the sun rarefying the atmosphere, and occasioning a continual influx of fresh air to fill up the vacuum; but very violent winds are frequently observed where no such cause can be supposed to exist. Thus on the tops of high mountains the winds are commonly very violent; and mountainous countries, especially when cold, are for the most part also subject to high winds. As the tops of mountains, however, are known to be strongly electrified by their attracting and repelling the clouds, we must suppose that this electricity has a considerable share in producing the winds which are generally so violent on their tops. This will appear the more probable when we consider that frequently storms of wind, and those of the most violent kind, seem to be brought along with clouds; as, for instance, that which happened at Malta, in 1780, in which a dreadful tempest, brought along with a large cloud, almost destroyed the whole town.

Thus we have endeavoured to give a general sketch of the doctrine of Meteorology: a more particular detail of the causes by which meteors are produced is given under the names of each of them as they occur in the order of the alphabet. With regard to their uses, those of the more magnificent and extensive kind seem to be destined to preserve the balance of the electric fluid in the atmosphere, the want of which would be productive of the most fatal effects to the world in general. The effects of the inferior ones are more confined, and are of use only to particular districts, scarcely ever extending their influence over a whole country. Thus the clouds, which produce rain for the purposes of vegetation, do not extend themselves over a whole country at once, but transitorily fly over different parts of it; so that when it rains, for instance, in one place, the sun may shine in another, thunder be heard in a third, &c. It is, however, surprising to observe how equally these act over the whole of a very large tract of land; so that though there is never precisely the same weather in two places twenty miles distant from one another, yet vegetation goes on without any perceptible difference in the one as well as the other; neither, unless there be some very remarkable difference in the weather of one year from that of another, will there be any perceptible difference in the crop. For a more particular investigation of this point, however, see the articles WINDS and WEATHER.

For the application of meteorology to the foreknowledge of the weather, see the articles WEATHER and BAROMETER.

METOPE, in *architecture;* the interval or square space between the triglyphs in the Doric frieze. The ancients were in the habit of ornamenting these parts of their buildings with carved works, or with paintings representing the heads of oxen, vessels, and other articles used in heathen sacrifices. The difficulty of disposing the triglyphs and metopes in symmetrical proportion may have been the cause of their omission in the Ionic and Corinthian orders.

METOPOSCOPY; the pretended art of divining from the wrinkles of the forehead. The Romans, believing in every kind of divination, practised this, but not so much as the people of the middle ages. It seems singular that metoposcopy never was so much in vogue as chiromancy, though there might be some possibility of divining, in part, the character of a man from his forehead and its wrinkles, while the lines in the hand have no connexion with it.

METRE; the French unit of measure. See MEASURES.

MEXICAL, or MESCAL; a spirituous drink, extracted from the aloe, which is consumed in large quantities by the Mexicans. It is also called *aguardiente de Maguey.*

MEZZO; an Italian adjective, which means *half,* and is often used in musical language, as *mezzo forte, mezzo piano, mezzo voce,* which imply nearly the same thing, viz. a middle degree of piano, or soft. *Mezzo soprano,* a pitch of voice between the soprano or treble and counter-tenor.

MIASMA; a term used in the doctrine of contagious and epidemic diseases, with different meanings. Some authors use it precisely like *contagion*· with others it signifies the contagious matter of chronic diseases; with others, that contagious matter which collects in the atmosphere—flying contagion. Some understand by *miasma,* the vehicle of contagion; for instance, the pus of small-pox, which contains the proper contagious matter.

Miasma also signifies certain matter in the atmosphere, owing its origin to putrefied animal or vegetable bodies, or to the exhalation of animal bodies, and producing specific diseases. It would be well to contradistinguish *miasma* from *contagion,* and designate by the former term all the poisonous matter of disease which is not generated in living animal bodies, but has in some other way entered the atmospheric air. One of the most powerful correctors of miasmatic effluvia is chloride of lime, which is getting much into use among surgeons and other persons exposed to such effluvia.

MICROMETER; an instrument by the help of which the apparent magnitudes of objects viewed through telescopes or microscopes are measured with great exactness.

1. The first *telescopic* micrometers were only mechanical contrivances for measuring the image of an object in the focus of the object-glass. Before these

MICROMETER.

Fig. 2.

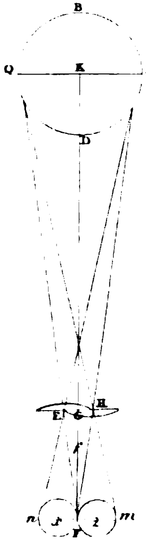


Fig. 6.

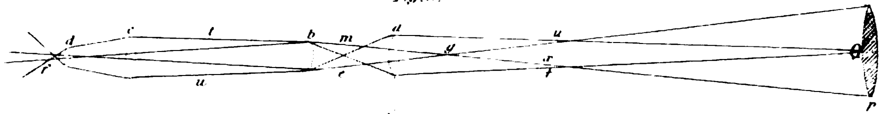


Fig. 10.

Fig. 3.

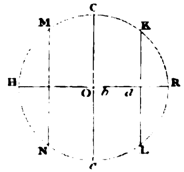
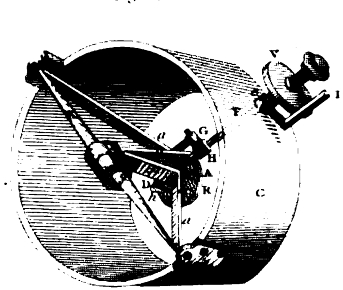


Fig. 4.



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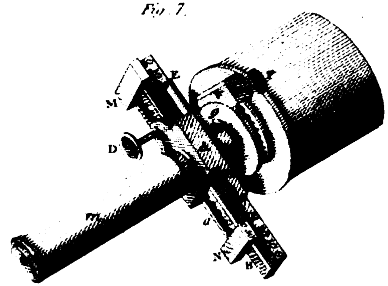


Fig. 8.

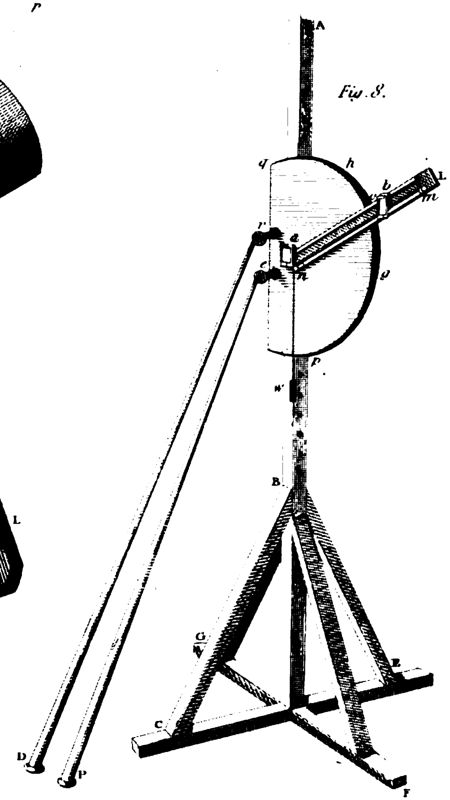
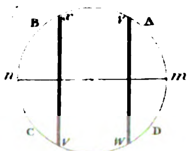


Fig. 1.



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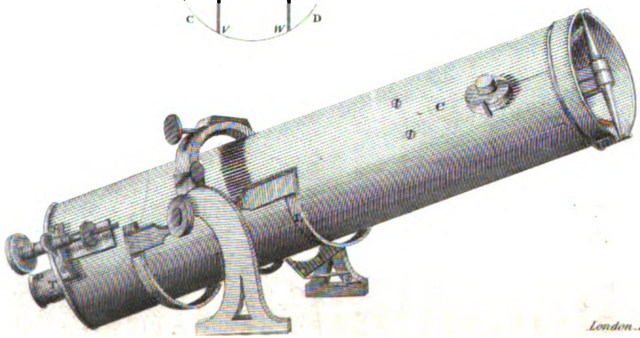
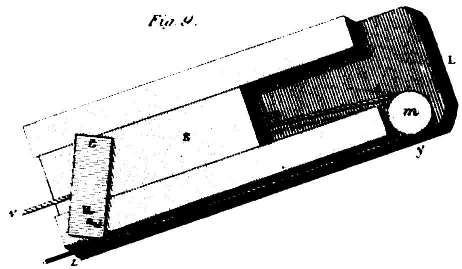


Fig. 9.



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contrivances were thought of, astronomers were accustomed to measure the field of view in each of their telescopes by observing how much of the moon they could see through it, the semidiameter being reckoned at fifteen or sixteen minutes; and other distances were estimated by the eye, comparing them with the field of view. Mr. Gascoigne, however, suggested a much more exact method, by which he could mark above 40,000 divisions in a foot.

Mr. Gascoigne's instrument being shown to Dr. Hooke, he gave a drawing and description of it, and proposed several improvements in it, which may be seen in the *Philosophical Transactions, Abr.*, vol. i., p. 217. Mr. Gascoigne divided the image of an object, in the focus of the object-glass, by the approach of two pieces of metal ground to a very fine edge, in the place of which Dr. Hooke substituted two fine hairs, stretched parallel to one another. An account of several curious observations that Mr. Gascoigne made by the help of his micrometer, particularly in the mensuration of the diameters of the moon and other planets, may be seen in the *Phil. Trans.*, vol. xlviii. p. 190.

Mr. Huygens, as appears by his *System of Saturn*, published in 1659, used to measure the apparent diameters of the planets, or any small angles, by first measuring the quantity of the field of view in his telescope, and then preparing two or three long and slender brass plates, of various breadths, the sides of which were very straight, and converging to a small angle. In making use of these pieces of brass he made them slide in two slits, that were made in the sides of the tube, opposite to the place of the image, and observed in what place it just covered the diameter of any planet, or any small distance that he wanted to measure. It was observed, however, by Sir Isaac Newton, that the diameters of planets, measured in this manner, must appear larger than they should be, as is the case with all lucid objects when they are viewed upon dark ones.

In the *Ephemerides* of the Marquis of Malvasia, published in 1662, it appears that he had a method of measuring small distances between fixed stars and the diameters of the planets, and also of taking accurate drawings of the spots on the moon; and this was by a net of silver wire, fixed in the common focus of the object and eye-glasses. He also contrived to make one of two stars to pass along the threads of this net, by turning it, or the telescope, as much as was necessary for that purpose; and he counted by a pendulum-clock, beating seconds, the time that elapsed in its passage from one wire to another, which gave him the number of the minutes and seconds of a degree contained between the intervals of the wires of his net, with respect to the focal length of his telescope.

In 1666, Messrs. Azout and Picard published a description of a micrometer, which was nearly the same with that of the Marquis of Malvasia, excepting the method of dividing it, which they performed with more exactness by a screw. In some cases they used threads of silk, as being finer than silver wires. Dechales also recommends a micrometer consisting of fine wires, or silken threads, the distances of which were exactly known, disposed in the form of a net, as peculiarly convenient for taking a map of the moon.

M. de la Hire says that there is no method more simple or commodious for observing the digits of an eclipse than a net in the focus of the telescope. This, he says, was generally made of silken threads, and for this particular purpose six concentric circles had also been made use of, drawn upon oiled paper; but he advises to draw the circles on very thin pieces of glass with the point of a diamond. He also gives several particular directions to assist persons in the use of them. In another memoir he shows a method of making use of the same net for all eclipses, by using a telescope with two object-glasses, and placing them at different distances from one another.

Different constructions of Micrometers.—The first we shall describe is that by Mr. Huygens. Let A B C D, *Plate* MICROMETER, *fig.* 1, be a section of the telescope at the principal focus of the object-glass, or where the wires are situated, which are placed in a short tube containing the eye-glass, and may be turned into any position by turning that tube; *m n* is a fine wire extended over its centre; *v w*, *x y*, are two straight plates, whose edges are parallel and well defined, and perpendicular to *m n*; *v w* is fixed, and *x y* moves parallel to it by means of a screw, which carries two indexes over a graduated plate, to show the number of revolutions and parts of a revolution which it makes. Now, to measure any angle, we must first ascertain the number of revolutions and parts of a revolution corresponding to some known angle, which may be thus done:—1st, Bring the inner edges of the plates exactly to coincide, and set each index to 0; turn the screw, and separate the plates to any distance, and observe the time a star, *m*, is in passing along the wire *m n* from one plate to the other; for that time, turned into minutes and seconds of a degree, will be the angle answering to the number of revolutions, or the angle corresponding to the distance. Thus, if $d =$ cos. of the star's declination, we have $15'\ dm$, the angle corresponding to this distance; and hence, by proportion, we find the angle answering to any other. 2dly, Set up an object of a known diameter, or two objects at a given distance, and turn the screw till the edges of the two plates become tangents to the object, or till their opening just takes in the distance of the two objects upon the wire *m n*; then from the diameter, or distance of the two objects from each other, and their distance from the glass, calculate the angle, and observe the number of revolutions and parts corresponding. 3dly, Take the diameter of the sun on any day, by making the edges of the plates tangents to the opposite limbs, and find from any astronomical almanac what is his diameter on that day. Here it will be best to take the upper and lower limbs of the sun when on the meridian, as he has then no motion perpendicular to the horizon. If the edges do not coincide when the indexes stand at 0, we must allow for the error. Instead of making a proportion, it is better to have a table calculated to show the angle corresponding to every revolution and part of a revolution. But the observer must remember that when the micrometer is fixed to telescopes of different focal lengths a new table must be made. The whole system of wires is turned about in its own plane by turning the eye-tube round with a hand, and by that means the wire, *m n*, can be thrown into any position, and consequently angles in any position may be measured. Dr. Bradley added a small motion by a rack and pinion to set the wires more accurately in any position.

The divided object-glass micrometer was originally contrived by the late Mr. John Dollond, and by him adapted to the object-end of a reflecting telescope. The principle is this:—The object-glass is divided into two segments in a line drawn through the centre; each segment is fixed in a separate frame of brass, which is movable, so that the centres of the two segments may be brought together by a handle for that purpose, and thereby form one image of an object; but when separated they will form two images, lying in a line passing through the centre of each segment; and consequently the motion of each image will be parallel to that line, which can be thrown into any position by the contrivance of another handle to turn the glass about in its own plane. The brass-work carries a vernier to measure the distance of the centres of the two segments. Now let E and H, *fig.* 2, be the centres of the two segments, F their principal focus, and P, Q, two distant objects in the line of FE, FH, or the opposite limbs of the same object PBQD; then the images of P and Q, formed by each segment, or the images of the opposite limbs of the object PBQD, coincide at F: hence two images *m z* F, *n x* F, of that object are formed, whose limbs are in contact; therefore the angular distance of the points P and Q is the same as the angle which the distance EH subtends at F, which, as the angles supposed to be measured are very small, will vary as EH or nearly so; and consequently, if the angle corresponding to one interval of the centres of the segments be known, the angle corresponding to any other will be found by proportion. Now to find the interval for some one angle, take the horizontal diameter of the sun on any day, by separating the images till the contrary limbs coincide, and read off by the vernier the interval of their centres, and look into the *Connoissance de tems* for the diameter of the sun on that day, and you have the corresponding angle. Or, if greater exactness be required than from taking the angle in proportion to the distances of the centres, we may proceed thus:—Draw FG perpendicular to EH, which therefore bisects it; then one half EH, or EG, is the tangent of half the angle EFH; hence, half the distance of their centres is to the tangent of half the angle corresponding to that distance as half any other distance of the centres is to the tangent of half the corresponding angle.

Hence the method of measuring small angles is manifest; for we consider P, Q, either as two objects whose images are brought together by separating the two segments, or as the opposite limbs of one object PBQ, whose images, formed by the two segments F, H, touch at F: in the former case, EH gives the angular distance of the two objects; and, in the latter, it gives the angle under which the diameter of the object appears. Hence, to find the angular distance of two objects, separate the segments till the two images which approach each other coincide; and, to find the diameter of an object, separate the segments till the contrary limbs of the images touch each other, and read off the distance of the centres of the segment from the vernier, and find the angle as directed in the last article. From hence appears one great superiority in this above the wire micrometer; as, with this, any diameter of an object may be measured with the same ease and accuracy; whereas with that we cannot with accuracy measure any diameter, except that which is at right angles to its apparent motion.

But, besides these uses to which the instrument seems so well adapted, Dr. Maskelyne has shown how it may be applied to find the difference of right ascensions and declinations. For this purpose, two wires at right angles to each other, bisecting the field of view, must be placed in the principal focus of the eye-glass, and movable about in their own plane.—Let HCR*c*, *fig.* 3, be the field of view, HR and C*c* the two wires; turn the wires till the westernmost star (which is the best, having further to move) runs along ROH; then separate the two segments and turn about the micrometer till the two images of the same star lie in the wire C*c*; and then, partly by separating the segments, and partly by raising or depressing the telescope, bring the two innermost images of the two stars to appear and run along ROH, as *a*, *b*, and the vernier will give the difference of their declinations: because, as the two images of one of the stars coincided with C*c*, the image of each star was brought perpendicularly upon HR, or to HR in their proper meridian. And, for the same reason, the difference of their times of passing the wire CO*c* will give their difference of right ascensions.

These operations will be facilitated if the telescope be mounted on a polar axis. If two other wires KL, MN, paralled to C*c*, be placed near H and R, the observation may be made on two stars whose difference of meridian is nearly equal to HR, the diameter of the field of view, by bringing the two images of one of the stars to coincide with one of these wires. If two stars be observed whose difference of declination is well settled, the scale of the micrometer will be known.

Hence the true place of a planet in the sun's disk may at any time of its transit be found; and consequently the nearest approach to the centre and the time of ecliptic conjunction may be deduced although the middle should not be observed.

But, however valuable the object-glass micrometer undoubtedly is, difficulties sometimes have been fouud in its use, owing to the alteration of the focus of the eye, which will cause it to give different measures of the same angle at different times.

In the *Philosophical Transactions* for 1779, Mr. Ramsden has described two new micrometers, which he contrived with a view of remedying the defects of the object-glass micrometer.

1. One of these is a *catoptric* micrometer, which, besides the advantage it derives from the principle of reflection, of not being disturbed by the mixed character of light, avoids every defect of other micrometers, and can have no aberration, nor any defect arising from the imperfection of materials or of execution, as the extreme simplicity of its construction requires no additional mirrors or glasses to those required for the telescope; and the separation of the image being effected by the inclination of the two specula, and not depending on the focus of any lens or mirror, any alteration in the eye of an observer cannot affect the angle measured. It has peculiar to itself the advantages of an adjustment to make the images coincide in a direction perpendicular to that of their motion, and also of measuring the diameter of a planet on both sides of the zero, which will appear no inconsiderable advantage to observers who know how much easier it is to ascertain the contact of the external edges of two images than their perfect coincidence.

A, *fig.* 4, represents the small speculum divided into two equal parts, one of which is fixed on the end of the arm B; the other end of the arm is fixed on a steel axis, X, which crosses the end of the telescope C. The other half of the mirror A is fixed on the arm D, which arm at the other end terminates in a socket, *y*, that turns on the axis X; both arms are prevented from bending by the braces *a*, *a*. G represents a double screw, having one part, *e*, cut into double the number of threads in an inch to that of the part *g*, the part *e* having 100 threads in one inch, and the part *g* fifty only. The screw *e* works in a nut F in the side of the telescope, while the part *g* turns in a nut H, which is attached to the arm B; the ends of the arms B and D, to which the mirrors are fixed, are separated from each other by the point of the double screw pressing against the stud *b*, fixed to the arm D, and turning in the nut H on the arm B. The two arms B and D are pressed against the direction of the double screw *e g* by a spiral spring within the part *n*, by which means all shake or play in the nut H, on which the measure depends, is entirely prevented.

From the difference of the threads on the screw at *e* and *g*, it is evident that the progressive motion of the screw through the nut will be half the distance of the separation of the two halves of the mirror; and consequently the half mirrors will be moved equally in contrary directions from the axis of the telescope C.

The wheel V fixed on the end of the double screw has its circumference divided into 100 equal parts, and numbered at every fifth division with five, ten, &c., to 100, and the index I shows the motion of the screw with the wheel round its axis, while the number of revolutions of the screw is shown by the divisions on the same index. The steel screw at R may be turned by a key, and serves to incline the small mirror at right angles to the direction of its motion. By turning the finger-head T (*fig.* 5), the eye-tube P is brought nearer to or further from the small mirror, to adjust the telescope to distinct vision; and the telescope itself has a motion round its axis for the conveniency of measuring the diameter of a planet in any direction. The inclination of the diameter measured with the horizon is shown in degrees and minutes by a level and vernier on a graduated circle, at the breech of the telescope.

"It is necessary to observe," says Mr. Ramsden, "that, besides the table for reducing the revolutions and parts of the screw to minutes, seconds, &c., it may require a table for correcting a very small error which arises from the eccentric motion of the half-mirrors. By this motion their centres of curvature will (when the angle to be measured is large) approach a little towards the large mirror: the equation for this purpose in small angles is insensible; but when angles to be measured exceed ten minutes it should not be neglected. Or the angle measured may be corrected by diminishing it in the proportion of the versed sine of the angle measured, taking into account the focal length of the small mirror."

Mr. Ramsden preferred Cassegrain's construction of the reflecting telescope to either the Gregorian or Newtonian, because, in the former, errors caused by one speculum are diminished by those in the other. From a property of the reflecting telescope (which, he observes, has not been attended to), that the apertures of the two specula are to each other very nearly in the proportion of their focal lengths, it follows that their aberrations will be to each other in the same proportion; and these aberrations are in the same direction if the two specula are both concave; or in contrary directions if one speculum is concave and the other convex. In the Gregorian construction, both specula being concave, the aberration at the second image will be the sum of the aberrations of the two mirrors; but in the Cassegrain construction, one mirror being concave and the other convex, the aberration at the second image will be the difference between their aberrations. By assuming such proportions for the *foci* of the specula as are generally used in the reflecting telescope, which is about as one to four, the aberration in the Cassegrain construction will be to that in the Gregorian as three to five.

2. The other is a *dioptric* micrometer, or one suited to the principle of refraction. This micrometer is applied to the erect eye-tube of a refracting telescope, and is placed in the conjugate focus of the first eye-glass; in which position, the image being considerably magnified before it comes to the micrometer, any imperfection in its glass will be magnified only by the remaining eye-glasses, which in any telescope seldom exceeds five or six times. By this position also the size of the micrometer glass will not be the $\frac{1}{100}$ part of the area which would be required if it were placed in the object-glass; and, notwithstanding this great disproportion of size, which is of great moment to the practical optician, the same extent of scale is preserved, and the images are uniformly bright in every part of the field of the telescope.

Fig. 6 represents the glasses of a refracting telescope; *x*, the principal pencil of rays from the object-glass O; *t t* and *u u*, the axis of two oblique pencils; *a*, the first eye-glass; *m*, its conjugate focus, or the place of the micrometer; *b*, the second eye-glass; *c*, the third; and *d*, the fourth, or that which is nearest the eye. Let *p* be the diameter of the object-glass, *e* the diameter of a pencil at *m*, and *f* the diameter of the pencil at the eye; it is evident that the axis of the pencils from every part of the image will cross each other at the point *m*; and *e* the width of the micrometer-glass is to *p* the diameter of the object-glass as *m a* is to *g o*, which is the proportion of the magnifying power at the point *m*; and the error caused by an imperfection in the micrometer glass placed at *m* will be to the error had the micrometer been at O as *m* is to *p*.

Fig. 7 represents the micrometer; A, a convex or concave lens, divided into two equal parts by a plane across its centre; one of these semi-lenses is fixed in a frame B, and the other in the frame E; which two frames slide on a plate H, and are pressed against it by thin plates *a*; the frames B and E are moved in contrary directions by turning the button D. L is a scale of equal parts on the frame B; it is numbered from each end towards the middle with 10, 20, &c. There are two verniers on the frame E, one at M and the other at N, for the convenience of measuring the diameter of a planet, &c., on both sides the zero. The first division on both these verniers coincides at the same time with the two zeros on the scale L; and, if the frame is moved towards the right, the relative motion of the two frames is shown on the scale

L by the vernier M; but, if the frame B be moved towards the left, the relative motion is shown by the vernier N.—This micrometer has a motion round the axis of vision for the convenience of measuring the diameter of a planet, &c., in any direction, by turning an endless screw, F; and the inclination of the diameter measured with the horizon is shown on the circle *g* by a vernier on the plate V. The telescope may be adjusted to distinct vision by means of an adjusting-screw, which moves the whole eye-tube with the micrometer nearer or further from the object-glass, as telescopes are generally made; or the same effect may be produced in a better manner without moving the micrometer, by sliding the part of the eye-tube *m* on the part *n*, by help of a screw or pinion. The micrometer is made to take off occasionally from the eye-tube that the telescope may be used without it.

The late Sir W. Herschel, having had much occasion for micrometers that would measure exceeding small distances exactly, was led to direct his attention to the improvement of these instruments; and the result of his endeavours has been a very ingenious instrument called a *lamp-micrometer*, which is not only free from the ordinary imperfections, but also possesses the advantages of a very large scale. This instrument is described in the *Philosophical Transactions* for 1782; and the construction of it is as follows:—

ABG, *fig*. 8, is a stand nine feet high, upon which a semicircular board, *qhogp*, is movable upwards or downwards, in the manner of some fire-screens, as occasion may require, and is held in its situation by a peg, *p*, put into any one of the holes of the upright piece AB. This board is a segment of a circle of fourteen inches radius, and is about three inches broader than a semicircle, to give room for the handles *rD*, *eP*, to work. The use of this board is to carry an arm L, thirty inches long, which is made to move upon a pivot at the centre of the circle, by means of a string, which passes in a groove upon the edge of the semicircle *pgohq*; the string is fastened to a hook at *o* (not shown in the figure, being at the back of the arm L), and passing along the groove from *o b* to *a* is turned over a pulley at *a* and goes down to a small barrel *e*, within the plane of the circular board, where a double-jointed handle, *e P*, commands its motion. By this contrivance, we see, the arm L may be lifted up to any altitude from the horizontal position to the perpendicular, or be suffered to descend by its own weight below the horizontal to the reverse perpendicular situation. The weight of the handle P is sufficient to keep the arm in any given position; but, if the motion should be too easy, a friction-spring applied to the barrel will moderate it at pleasure.

In front of the arm L, a small slider, about three inches long, is movable in a rabbet from the end L towards the centre backwards and forwards. A string is fastened to the left side of the little slider, and goes towards L, where it passes round a pulley at *m*, and returns under the arm from *m*, *n*, towards the centre, where it is led in a groove on the edge of the arm, which is of a circular form, upwards to a barrel (raised above the plane of the circular board) at *r*, to which the handle *rD* is fastened. A second string is fastened to the slider, at the right side, and goes towards the centre, where it passes over a pulley *n*; and the weight *w*, which is suspended by the end of this string, returns the slider towards the centre, when a contrary turn of the handle permits it to act.

At *a* and *b* are represented two small lamps, two inches high, 1½ in breadth by 1¼ in depth. The sides, back, and top, are made so as to permit no light to be seen, and the front consists of a thin brass sliding door. The flame in the lamp *a* is placed three-tenths of an inch from the left side, three-tenths from the front, and half an inch from the bottom. In the lamp *b* it is placed at the same height and distance, measuring from the right side. The wick of the flame consists only of a single very thin lamp-cotton thread: for, the smallest flame being sufficient, it is easier to keep it burning in so confined a place. In the top of each lamp must be a little slit lengthways, and also a small opening in one side near the upper part, to permit air enough to circulate to feed the flame. To prevent every reflection of light, the side opening of the lamp *a* should be to the right, and that of the lamp *b* to the left. In the sliding door of each lamp is made a small hole with the point of a very fine needle just opposite the place where the wicks are burning, so that when the sliders are shut down, and every thing dark, nothing shall be seen but two fine lucid points of the size of two stars of the third or fourth magnitude. The lamp *a* is placed so that its lucid point may be in the centre of the circular board, where it remains fixed. The lamp *b* is hung to the little slider which moves in the rabbet of the arm, so that its lucid point, in an horizontal position of the arm, may be on a level with the lucid point in the centre. The movable lamp is suspended upon a piece of brass fastened to the slider by a pin exactly behind the flame, upon which it moves as a pivot. The lamp is balanced at the bottom by a leaden weight, so as always to remain upright when the arm is either lifted above or depressed below the horizontal position. The double-jointed handle *rD*, *eP*, consists of light deal rods, ten feet long, and the lowest of them may have divisions marked upon it near the end P, expressing exactly the distance from the central lucid point in feet, inches, and tenths.

From this construction we see that a person at a distance of ten feet may govern the two lucid points, so as to bring them into any required position south or north, preceding or following from 0 to 90° by using the handle P, and also to any distance from six-tenths of an inch to five or six and twenty inches by means of the handle D. If any reflection or appearance of light should be left from the top or sides of the lamps, a temporary screen, consisting of a long piece of pasteboard, or a wire frame covered with black cloth, of the length of the whole arm, and of any required breadth, with a slit of half an inch broad in the middle, may be affixed to the arm by four bent wires, projecting an inch or two before the lamps, situated so that the movable lucid point may pass along the opening left for that purpose.

Fig. 9 represents part of the arm L, half the real size; S the slider; *m* the pulley, over which the cord *xtyz* is returned towards the centre; *v* the other cord going to the pulley *n* of *fig*. 8; R the brass piece movable upon the pin *c*, to keep the lamp upright. At R is a wire riveted to the brass piece, upon which is held the lamp by a nut and screw.

"Every artist," says the ingenious inventor, "will soon perceive that the motions of this micrometer are

capable of great improvement by the application of wheels and pinions, and other well known mechanical resources; but as the principal object is only to be able to adjust the two lucid points to the required position and distance, and to keep them there for a few minutes, while the observer measures their distance, it will not be necessary to say more upon the subject.

"I am now to show the application of this instrument. It is well known to opticians, and others who have been in the habit of using optical instruments, that we can with one eye look into a microscope or telescope, and see an object much magnified, while the naked eye may see a scale upon which the magnified picture is thrown. In this manner I have generally determined the power of my telescopes; and any one who has acquired a facility of taking such observations will very seldom mistake so much as one in fifty in determining the power of an instrument, and that degree of exactness is fully sufficient for the purpose.

"The Newtonian form is admirably adapted to the use of this micrometer; for the observer stands always erect, and looks in a horizontal direction, notwithstanding the telescope should be elevated to the zenith. Besides, his face being turned away from the object to which his telescope is directed, this micrometer may be placed very conveniently without causing the least obstruction to the view: therefore, when I use this instrument, I put it at ten feet distance from the left eye, in a line perpendicular to the tube of the telescope, and raise the movable board to such a height that the lucid point of the central lamp may be upon a level with the eye. The handles, lifted up, are passed through two loops fastened to the tube, just by the observer, so as to be ready for his use. I should observe that the end of the tube is cut away, so as to leave the left eye entirely free to see the whole micrometer.

"Having now directed the telescope to a double star, I view it with the right eye, and at the same time with the left see it projected upon the micrometer: then, by the handle P, which commands the position of the arm, I raise or depress it so as to bring the two lucid points to a similar situation with the two stars; and, by the handle D, I approach or remove the movable lucid point to the same distance of the two stars, so that the two lucid points may be exactly covered by or coincide with the stars. A little practice in this business soon makes it easy, especially to one who has already been used to look with both eyes open.

"What remains to be done is very simple. With a proper rule, divided into inches and fortieth parts, I take the distance of the lucid points, which may be done to the greatest nicety, because, as I observed before, the little holes are made with the point of a very fine needle. The measure thus obtained is the tangent of the magnified angle under which the stars are seen to a radius of ten feet; therefore, the angle being found, and divided by the power of the telescope, gives the real angular distance of the centres of a double star."

Mr. Cavallo invented a micrometer which consists of a thin and narrow slip of mother of pearl finely divided, and situated in the focus of the eye-glass of a telescope, just where the image of the object is formed. It is immaterial whether the telescope be a refractor or a reflector, provided the eye-glass be a convex lens, and not a concave one, as in the Galilean construction.

The simplest way of fixing it is to stick it upon the diaphragm, which generally stands within the tube and in the focus of the eye-glass. When thus fixed, if you look through the eye-glass, the division of the micrometrical scale will appear very distinct, unless the diaphragm is not exactly in the focus; in which case, the micrometrical scale must be placed exactly in the focus of the eye-glass, either by pushing the diaphragm backwards or forwards, when this is practicable; or else the scale may be easily removed from one or the other surface of the diaphragm by the interposition of a circular piece of paper or card, or by a bit of wax. This construction is fully sufficient, when the telescope is always to be used by the same person; but, when different persons are to use it, then the diaphragm which supports the micrometer must be constructed so as to be easily moved backwards or forwards, though that motion need not be greater than about a tenth or an eighth of an inch. This is necessary, because the distance of the focus of the same lens appears different to the eyes of different persons; and, therefore, whoever is going to use the telescope for the mensuration of any angle must first of all unscrew the tube which contains the eye-glass and micrometer from the rest of the telescope, and, looking through the eye-glass, must place the micrometer where the divisions of it may appear quite distinct to his eye.

Fig. 10 exhibits this micrometer scale, but shows it twice the real size of one which Mr. Cavallo adapted to a three-feet achromatic telescope magnifying about eighty-four times. It is something less than the twenty-fourth part of an inch broad; its thickness is equal to that of common writing-paper; and the length of it is determined by the aperture of the diaphragm, which limits the field of the telescope. The divisions upon it are the 200ths of an inch, which reach from one edge of the scale to about the middle of it, excepting every fifth and tenth division, which are longer. The divided edge of it passes through the centre of the field of view, though this is not a necessary precaution in the construction of this micrometer.

In looking through a telescope furnished with such a micrometer, the field of view appears divided by the micrometer scale, the breadth of which occupies about one-seventh part of the aperture; and, as the scale is semi-transparent, that part of the object which happens to be behind it may be discerned sufficiently well to ascertain the division, and even the quarter of a division, with which its borders coincide.

At first view, the observer is apt to imagine that it is difficult to count the divisions which may happen to cover or to measure an object; but, upon trial, it will be found that this is readily performed; and even those persons who have never been used to observe with the telescope soon learn to measure very quickly and accurately with this micrometer; for, since every fifth and tenth division is longer than the rest, the astronomer soon acquires the habit of saying five, ten, fifteen; and then adding the other divisions less than five completes the reckoning. Even with a telescope which has no stand, if the object end of it be rested against a steady place, and the other end be held by the hand near the eye of the observer, an object may be measured with accuracy sufficient for several purposes, as

for the estimation of small distances, for determining the height of a house, &c. (See TELESCOPE.)

II. The micrometer has not only been applied to telescopes, and employed for astronomical purposes, but there have also been various contrivances for adapting it to *microscopical* observations. Mr. Leeuwenhoek's method of estimating the size of small objects was by comparing them with grains of sand, of which 100 in a line took up an inch. These grains he laid upon the same plate with his objects, and viewed them at the same time. Dr. Jurin's method was similar to this; for he found the diameter of a piece of fine silver wire, by wrapping it as close as he could about a pin, and observing how many rings made an inch; and he used this wire in the same manner as Leeuwenhoek used his sand. Dr. Hooke used to look upon the magnified object with one eye, while at the same time he viewed other objects placed at the same distance with the other eye. In this manner he was able, by the help of a ruler, divided into inches and small parts, and laid on the pedestal of the microscope, to cast as it were the magnified appearance of the object upon the ruler, and thus exactly to measure the diameter which it appeared to have through the glass, which being compared with the diameter as it appeared to the naked eye easily showed the degree in which it was magnified. "A little practice," says Mr. Baker, "will render this method exceedingly easy and pleasant."

"The mode of actual admeasurement," observes Mr. Adams in his *Microscopical Essays*, page 59, "is without doubt the most simple that can be used; as by it we comprehend, in a manner, at one glance, the different effects of combined glasses; and as it saves the trouble, and avoids the obscurity, of the usual modes of calculation."

The only other instrument which our space permits us to describe consists of a screw, which has fifty threads to an inch; this screw carries an index, which points to the divisions on a circular plate, which is fixed at right angles to the axis of the screw. The revolutions of the screw are counted on a scale, which is an inch divided into fifty parts; the index to these divisions is a fleur-de-lis marked upon the slider, which carries the needle-point across the field of the microscope. Every revolution of the micrometer screw measures one-fiftieth part of an inch, which is again subdivided by means of the divisions on the circular plate, as this is divided into twenty equal parts, over which the index passes at every revolution of the screw; by which means we obtain with ease the measure of 1000th part of an inch: for fifty, the number of threads on the screw, being multiplied by twenty, the divisions on the circular plate, are equal to 1000; so that each division on the circular plate shows that the needle has either advanced or receded 1000th part of an inch. (See MICROSCOPE.)

MICROSCOPE. The history of this instrument is veiled in considerable obscurity, and among the moderns the discovery of the microscope has been claimed by several individuals. The ancients appear to have been acquainted with it in one of its forms; for Seneca says, "Letters, though minute and obscure, appear larger and clearer through a glass bubble filled with water." In the middle ages this knowledge was lost. The invention of the modern instrument is attributed by the celebrated Dutch mathematician Huygens to a countryman of his, named Drebell, who constructed them about 1621, or thirty-one years after the invention of the telescope. Borelli attributes it to Jansen, the reputed contriver of the telescope; Viviani to Galileo. The first compound microscope consisting of two double convex lenses seems to have been made by F. Fontana, a Neapolitan, who dates his invention from 1618.

The numerous forms of microscopes may be included under the heads of single, compound refracting, and compound reflecting microscopes. The theory of the *single microscope* may be thus explaned. We all know that at a small distance we see more distinctly than at a large. If we look at two men, one 200 feet distant, the other 100 feet, the former will appear only one half the height of the latter, or the angle which the latter subtends to the eye of the observer will be twice that subtended by the former. Hence we must conclude that the nearer we can bring an object to the eye the larger it will appear. Now if, to render the parts of a minute object distinguishable, we bring it very near the eye (suppose within one or two inches), it will become very indistinct and confused, in consequence of the great divergence of the rays of light from the object, and the power of the crystalline lens of the eye not being sufficient to collect the rays whereby an image of the object may be formed on the retina at the proper distance on the back of the eye. Now if we employ a single microscope, which consists of a convex lens, usually made of glass (though any other transparent substance would have the same power in a greater or less degree), and mounted in a brass setting, and place it between the object and the eye, the former being in the focus of the glass, the diverging rays from the object will be refracted and rendered parallel by the lens, and thus we shall obtain a distinct and near view of the object. The increase of apparent magnitude obtained by the employment of lenses is proportioned to the difference of the distance of an object from the lens and the distance when seen without its assistance. This latter distance (the distance of distinct vision of minute objects with the naked eye) varies in different persons, and at different periods of life. Some measure therefore must be assumed as a standard, before we can express the amplifying power of a lens so as mutually to have the same idea of the magnitude of an object. Some authors adopt ten inches as the standard of the focus of the eye, under ordinary circumstances, and its decimal character makes it a convenient multiplier or divisor. With this decimal standard we can determine the magnifying power of lenses of any focal length, or formed of any substance (media). Thus if we have a lens which requires for distinct vision the object to be one inch from its centre (in a double convex), we must divide the standard ten by one, which will give ten as the magnifying power. If the lens require the object to be $\frac{1}{25}$th of an inch distant, its magnifying power will be 250. We have called the magnifying power in the first instance ten, because the length of the object is increased ten times; but, as its breadth is also increased ten times, the real magnifying power of the lens is ten times ten, or 100. The common form of the magnifiers employed for microscopes is double-convex, and they should be made as thin as possible; for the wandering or spreading out of the rays proceeding from an object when refracted by a lens with spherical surfaces, whereby an indistinctness is produced in its image, will be decreased, as the square of the thickness of the lens

employed, and the loss of light in passing through the lens is less in proportion as it is thin.

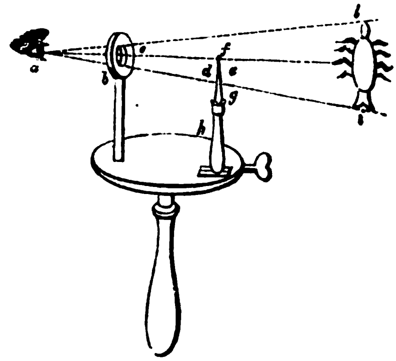
Within a few years, diamonds have been formed into lenses in consequence of their high refractive power, whereby we can obtain lenses of any degree of magnifying power with comparatively shallow curves; and, as the dispersion of colour in this substance is very low, the lens is nearly achromatic. Next to the diamond the sapphire possesses all the powers requisite for the formation of perfect magnifiers, and presents less difficulty in their construction; hence the expense of employing it is considerably less.

A *compound refracting microscope* is an instrument consisting of two or more convex lenses, by one of which an enlarged image of the object is formed, and then by means of the other, employed as an eye-glass, a magnified representation of the enlarged image is obtained. The distance at which the two lenses of a compound microscope are placed from each other must always exceed the sum of their focal lengths, in order that the image may be formed by the object-glass in the anterior focus of the eye-glass. Compound microscopes have been constructed of almost all possible dimensions, from a few inches in length to twenty feet; but from experience it appears that whenever their magnitude is augmented beyond a certain point the effect is diminished, though we suppose the amplifying power of both microscopes the same.

The *solar microscope* consists of a common microscrope connected with a reflector and condenser, the former being used to throw the sun's light on the latter, by which it is condensed to illuminate the object placed in its focus. This object is also in the focus of the microscopic lens on the other side of it, which transmits a magnified image of it to a wall or screen (sometimes a combination of two magnifying lenses is used). The magnifying power will be greater in proportion as the focal distance of the object-glass compared with the distance of the wall or screen from the object-glass is less. The principle of the *lucernal microscope* is the same, except that a lamp is used instead of the sun to illuminate the objects; this lamp is enclosed in a lantern, to screen the light from the observers.

Having thus given a general outline of the arrangement of the microscope in its various forms, it will now be advisable to furnish our readers with such graphic and descriptive particulars as will enable any ingenious workman, reading this article in conjunction with our treatise on OPTICS, to construct the instrument. To render this systematic and intelligible it may be advisable to commence with the most simple form.

A very convenient form of microscope is shown in the following engraving, where *b* is a circular piece of brass or ivory, in the middle of which is a small hole, one-twentieth of an inch diameter: in this hole is fixed, with a wire, a small lens, whose focal distance is *c d*. At that point is placed a pair of pliers, *g h*, which may be adjusted by means of the sliding screw, as in the figure, and opened by means of two little studs. The object may be viewed with the eye placed in the other focus of the lens at *a*; and, according to the focal length of the lens, the object *f* will appear more or less magnified, as represented at *i l*. If the focal length be half or one-fourth of an inch, the length, surface, and bulk of the object will be magnified in a similar proportion. This small instrument may be put into a case for the pocket. Those lenses whose focal lengths are three-tenths, four-tenths, and five-tenths of an inch, are the best for common use.



Since the nearer the eye can approach to an object the larger it appears, it is plain, a double and equally convex lens magnifies more than a plano-convex lens; because, if the sphere, or convexity, be the same, the focal length of the former is but half that of the latter; and, since the double convex consists of two segments of a sphere, the more an object is to be magnified the greater must the convexity be, and therefore the smaller the sphere; till at last the utmost degree of magnifying power will require that these segments become hemispheres, and, consequently, the lens will be reduced to a perfect spherule, or very small sphere.

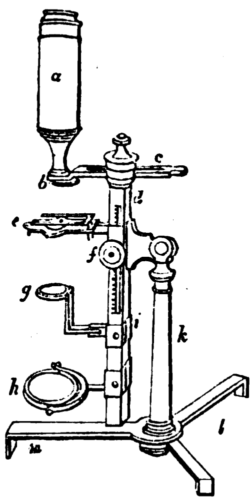
If the radius of the spherule be one-tenth of an inch, the eye will have distinct vision of an object by means thereof, at the distance of $1\frac{1}{2}$ radius (that is, three-twentieths of an inch), and, as this is but the fortieth part of six inches, the length of an object will be magnified forty times, the surface 1600 times, and the solidity 64,000 times, by such a small sphere.

If the radius of a spherule be but one-twentieth of an inch, then will the eye have distinct vision of an object at the distance of three-fortieths of an inch, and, as this is but the eightieth part of six inches, the length of objects will appear eighty times greater, the surface 6400 times, and the bulk 512,000 times greater, to the naked eye at six inches distance.

In using these spherule microscopes, the objects are to be placed in one focus and the eye in the other; and, since the focus is so exceedingly near the glass, it is impossible to view any but pellucid bodies; for, if any opaque object were to be applied, the eye being, as it were, just on the spherule, would entirely prevent any light falling on it, and it would be too obscure to be viewed.

To remedy this inconvenience, the focal length should be increased and a concave mirror substituted for the plate *b*. The object *f*, being placed in the focus of the mirror, is illuminated by reflected light, and the most opaque insect may thus be seen with advantage to the naturalist. If the instrument thus arranged be directed towards the sun, the effect will be very materially improved; and, when this cannot be accomplished, a sheet of white paper should be placed beneath the instrument.

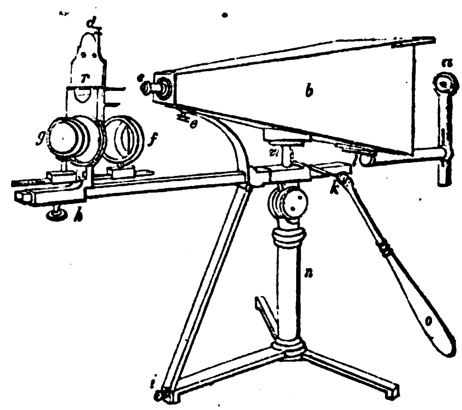
The *compound-microscope*, as made by Messrs. Jones, of Holborn, is shown in the engraving beneath. The body of the instrument *a* is screwed to the horizontal sliding arm *c*. At *b* is a circular plate, containing a series of glasses, varying in their magnifying power. The objects to be magnified are placed in the stage *e*, and the proper focus obtained by moving the rack at *f d*. The lens *g* is employed to concentrate the light of a lamp, or that of the sun, on the object to be examined. The reflector at *h* has two mirrors, the one concave, the other flat. The whole instrument is supported by the pillar *k* and the triangular stand *l m*.



The great facility with which objects can be represented on paper, or a rough glass, in the camera obscura, and copies drawn from them by any person, though unskilled in drawing, evidently suggested the application of the microscope to this instrument. The greatest number of experiments that appear to have been made with this view were by Mr. Martin and Mr. Adams, the former of whom frequently applied the microscope to the portable camera, and with much effect. But, these instruments being found to answer only with the assistance of the sun, Mr. Adams directed his experiments to the construction of an instrument of more extended utility, which could be equally employed in the day and by night. He accordingly succeeded so far as to produce, by candle-light, the images of objects refracted from a single magnifier, upon one or two large convex lenses (of about five inches, or upwards, in diameter), at the end of a pyramidal-shaped box, in a very pleasing manner, so as to give opaque objects, as well as transparent ones, the utmost distinctness of representation: but still the light of a candle, or lamp, was found generally insufficient to throw the requisite degree of illumination on the objects. The invention of the Argand lamp offered a complete remedy for this defect, by the intensity and steadiness of its light.

The advantages of this excellently-conceived instrument are numerous and important. "As the far greater part of the objects which surround us are opaque," says Mr. Adams, "and very few are sufficiently transparent to be examined by the common microscopes, an instrument that could be readily applied to the examination of opaque objects has always been a desideratum. Even in the examination of transparent objects, many of the fine and more curious portions are lost, and drowned, as it were, in the light which must be transmitted through them; while different parts of the same object appear only as dark lines or spots, because they are so opaque as not to permit any light to pass through them. These difficulties, as well as many more, are obviated in the lucernal microscopes, by which opaque objects of various sizes may be seen with ease and distinctness, the beautiful colours with which most of them are adorned are rendered more brilliant, without changing in the least the real tint of the colour, and the concave and convex parts retain also their proper form. The facility with which all opaque objects are applied to this instrument is another considerable advantage, and almost peculiar to itself: as the texture and configuration of the more tender parts are often hurt by previous preparation, every object may be examined by this instrument first as opaque, and afterwards (if the texture will admit of it) as transparent.—The lucernal microscope does not in the least fatigue the eye; the object appears like nature itself, giving ease to the sight and pleasure to the mind: there is also, in the use of this instrument, no occasion to shut the eye which is not directed to the object. A further advantage peculiar to this microscope is that by it the outlines of every object may be taken, even by those who are not accustomed to draw; while those who can draw well will receive great assistance, and execute their work with more accuracy and in less time than they would otherwise have been able to have performed it. Transparent objects as well as opaque may be copied in the same manner. The instrument may be used at any time of the day, but the best effect is by night; in which respect it has a superiority over the solar microscope, as that instrument can be used only when the sun shines.

"Transparent objects may be examined with the lucernal microscope in three or four different modes, from a blaze of light almost too great for the eye to bear to that which is perfectly easy to it; and, by the addition of a tin lantern to the apparatus, may be thrown on a screen, and exhibited at one view to a large company, as by the solar microscope."

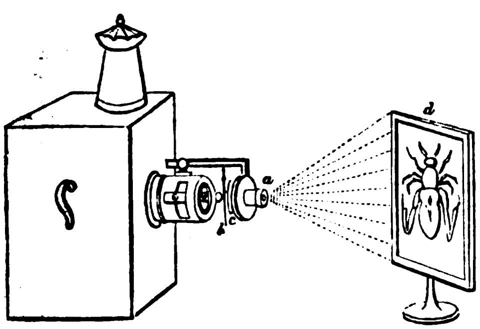


In the above engraving we give a view of this instrument mounted to examine opaque objects. *b* is a large mahogany pyramidal box, which forms the body of the microscope; it is supported firmly on the brass pillar *n*, by means of the socket *m* and the curved piece *e*. *a* is a guide for the eye, in order to direct it in the axis of the lenses; it consists of two brass tubes, *l*, one sliding within the other, and a vertical flat piece, at the top of which is the hole for the eye. The inner tube may be pulled out, or pushed in, to adjust it to the focus of the glasses. The vertical piece may be raised or depressed, that the hole

through which the object is to be viewed may coincide with the centre of the field of view: it is moved by a milled screw, which could not be shown in this figure. At *l* is a dove-tailed piece of brass, made to receive the dove-tail at the end of the tubes, by which it is attached to the wooden box. The tubes may be removed from this box occasionally, for the convenience of packing it up in a less compass. At the small end of the cone is placed a tube which carries the magnifiers, one of which is represented at *c*; the tube may be unscrewed occasionally from the wooden body. Beneath the cone is placed a long square bar, which passes through, and carries the stage or frame that holds the objects; this bar may be moved backward or forward, in order to adjust it to the focus, by means of the pinion *k*. A handle furnished with a universal joint, for more conveniently turning the pinion, is shown at *o*. When the handle is removed a nut may be used in its stead. The stage *h* for opaque objects fits upon the bar by means of a socket, and is brought nearer to or removed further from the magnifying lens by turning the pinion *k*: the objects are placed in the front side of the stage. The two upper pieces of brass, *r*, are movable; they are fixed to a plate, which is acted on by a spiral spring, that presses them down and confines the slider with the objects: this plate, and the two upper pieces of brass, are lifted up by the small nut *d*.

At the lower part of the stage, there is a semicircular lump of glass, *g*, which is designed to receive the light from the lamp, and to collect and throw it on the concave mirror *f*, whence it is reflected on the object. The upper part of the opaque stage takes out, that the stage for transparent objects may be inserted in its place.

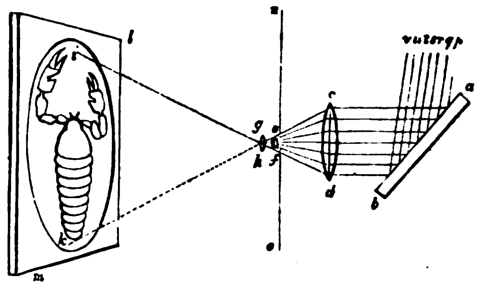
Another still more simple mode of effecting the same object is shown beneath:



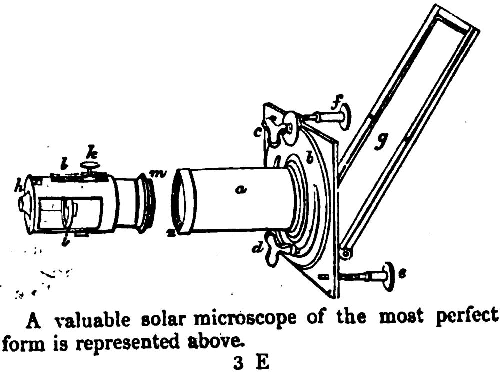
The lantern is provided with a sliding tube for the introduction of the objects to be magnified. The movable lenses are shown at *a*. Other objects differing in their character may be placed in the forceps *b*, attached to the sliding frame by the plate *c*. A plate of ground glass, shown at *d*, serves to receive the figure of the object.

The more recent application of a jet of oxy-hydrogen, acting on a ball or cylinder of lime, would not be understood by the reader without a previous acquaintance with both these gases. The editor, therefore, purposes describing a large and powerful apparatus of this description, which he has had constructed for his public lectures, under the article OXY-HYDROGEN.

The mode of constructing the *solar microscope* may now be illustrated.



It is shown in its simplest form in the above engraving, in which *a b* is the diagonal mirror for receiving the rays of light, *p q r s t u v*. They are reflected by the polished surface, and thrown on the lens *c d*. Within the focus at *e f* is placed any transparent object to be magnified, and the image thus illuminated passes through the lens *g h*. The size of the magnified figure, *i k*, will depend on the distance the instrument is placed from the wall *l m*. The room should be darkened, which is usually effected by employing a large shutter at *n o*. Mr. Baker, speaking of this instrument, says, "that it has conveniences attending it which no other microscope can have: for the weakest eyes may use it without the least straining or fatigue: numbers of people together may view any object at the same time; and, by pointing to the particular parts thereof, and discoursing on what lies before them, may be able better to understand one another, and more likely to find out the truth, than in other microscopes, where they must peep one after another, and perhaps see the object neither in the same light nor in the same position. Those, also, who have no skill in drawing, may by this contrivance easily sketch out the exact figure of any object they have a mind to preserve a picture of, since they need only fasten a paper on the screen, and trace it out thereon either with a pen or pencil, as it appears before them. It is worth the while of those who are desirous of taking many draughts in this way to get a frame, in which a sheet of paper may be placed or taken out at pleasure; for, if the paper be single, the image of an object will be seen almost as plainly on the back as on the fore-side; and, by standing behind the screen, the shade of the hand will not obstruct the light in drawing, as it must in some degree when one stands before it."



A valuable solar microscope of the most perfect form is represented above.

The square plate *b c d* is attached to the window-shutter by the screws *e f*. The glass plate *g* is mounted in a brass frame, and may be elevated or depressed by a screw at *d*. A rotatory motion is communicated by a pinion and handle at *c*, which acts on a large wheel, concealed by the square plate. The first lens is placed in the tube *a*, immediately adjoining the mirror. Another tube *m* is attached by a screw at *n*, and contains two small lenses, and the rack-work *k l* for adjusting the focus of the instrument. The objects are introduced at *i*; those best fitted for exhibition are the wings of insects, and the cuttings of wood. When glasses of high-power are employed at *h*, they are now constructed on the achromatic principle.

We may now proceed to furnish our readers with some necessary particulars respecting the method of using microscopes. On this, Mr. Adams, in his *Essay on the Microscope*, has been very copious; with a view, as he informs us, to remove the common complaint made by Mr. Baker, "that many of those who purchase microscopes are so little acquainted with their general and extensive usefulness, and so much at a loss for objects to examine by them, that after diverting their friends some few times with what they find in the sliders which generally accompany the instrument, or perhaps with two or three common objects, the microscope is laid aside as of little further value; whereas no instrument has yet appeared in the world capable of affording so constant, various, and satisfactory an entertainment to the mind."

In using the microscope, there are three things necessary to be considered. 1. The preparation and adjustment of the instrument itself. 2. The proper quantity of light, and the best method of adapting it to the object. 3. The method of preparing the objects, so that their texture may be properly understood.

With regard to the microscope itself, the first thing necessary to be examined is whether the glasses be clean or not: if they are not so, they must be wiped with a piece of soft leather, taking care not to soil them afterwards with the fingers; and, in replacing them, care must be taken not to place them in an oblique direction. We must likewise be careful not to let the breath fall upon the glasses, nor to hold that part of the body of the instrument where the glasses are placed with a warm hand; because the moisture thus expelled by the heat from the metal will condense upon the glass, and prevent the object from being distinctly seen. The object should be brought as near the centre of the field of view as possible; for there only will it be exhibited in the greatest perfection. The eye should be moved up and down from the eye-glass of a compound microscope, till the situation is found where the largest field and most distinct view of the object are to be had: but every person ought to adjust the microscope to his own eye, and not depend upon the situation it was placed in by another. A small magnifying power should always be begun with; by which means the observer will best obtain an exact idea of the situation and connexion of the whole, and will of consequence be less liable to form any erroneous opinion, when the parts are viewed separately by a lens of greater power. Objects should also be examined first in their most natural position; for, if this be not attended to, we shall be apt to form very erroneous ideas of the structure of the whole, as well as of the connexion and use of the parts. A living animal ought to be as little hurt or discomposed as possible. From viewing an object properly, we may acquire a knowledge of its nature: but this cannot be done without an extensive knowledge of the subject, much patience, and many experiments; as in a great number of cases the images will resemble each other, though derived from very different substances. Mr. Baker, therefore, advises us not to form an opinion too suddenly, after viewing a microscopical object; nor to draw our inferences till after repeated experiment and examinations of the objects in many different lights and positions; to pass no judgment upon things extended by force, or contracted by dryness, or in any manner out of a natural state, without making suitable allowances. The true colour of objects cannot be properly determined by very great magnifiers; for, as the pores and interstices of an object are enlarged according to the magnifying power of the glasses made use of, the component particles of its substance will appear separated many thousand times further asunder than they do to the naked eye: hence the reflection of the light from these particles will be very different, and exhibit different colours. It is likewise somewhat difficult to observe opaque objects; and, as the apertures of the larger magnifiers are but small, they are not proper for the purpose. If an object be so very opaque that no light will pass through it, as much as possible must be thrown upon the upper surface of it. Some consideration is likewise necessary in forming a judgment of the motion of living creatures, or even of fluids, when seen through the microscope; for, as the moving body, and the space wherein it moves, are magnified, the motion will also be increased.

On the management of the light depends, in a great measure, the distinctness of the vision: and as, in order to have this in the greatest perfection, we must adapt the quantity of light to the nature of the object and the focus of the magnifier, it is therefore necessary to view it in various degrees of light. In some objects, it is difficult to distinguish between a prominence and a depression, a shadow and a black stain; or between a reflection of light and whiteness, which is particularly observable in the eye of the libella and other flies, all of these appearing very different in one position from what they do in another. The brightness of an object likewise depends on the quantity of light, the distinctness of vision, and on regulating the quantity to the object; for one will be in a manner lost in a quantity of light scarcely sufficient to render another visible.

There are various ways in which a strong light may be thrown upon objects, as by means of the sun and a convex lens. For this purpose, the microscope is to be placed about three feet from a southern window; then take a deep convex lens, mounted on a semicircle and stand, so that its position may easily be varied: place this lens between the object and the window, so that it may collect a considerable number of rays, and refract them on the object or the mirror of the microscope. If the light thus collected from the sun be too powerful, it may be lessened by placing a piece of oiled paper, or a piece of glass slightly ground, between the object and lens. Thus a proper degree of light may be obtained, and diffused equally over the surface of an object, a circumstance which ought to be particularly attended to; for, if the light be thrown irregularly upon it, no distinct view can be obtained.

On account of the sun's motion, and the variable state of the atmosphere, solar observations are rendered both tedious and inconvenient, so that it may be advisable for the observer to be furnished with a large tin lantern, formed something like the common magic lantern, capable of containing an argand lamp. There ought to be an aperture in the front of the lantern, which may be moved up and down, and be capable of holding a lens, by which means a pleasant and uniform as well as strong light may easily be obtained. The lamp should likewise move on a rod, so that it may be easily raised or depressed. A weak light is best fitted for viewing many transparent objects, among which we may reckon the prepared eyes of flies, as well as the animalculæ in fluids. The quantity of light from a lamp or candle may be lessened by removing the microscope to a greater distance from them, or by diminishing the strength of the light which falls upon the objects. This may very conveniently be done by pieces of black paper with circular apertures of different sizes, and placing a larger or smaller one upon the reflecting mirror, as occasion may require. The light of a lamp or candle is generally better for viewing microscopic objects than day-light, it being more easy to modify the former than the latter, and to throw it upon the object with different degrees of intensity.

With regard to the preparation of objects, Swammerdam has, in that respect, excelled almost all other investigators who either preceded or have succeeded him. He was so assiduous and indefatigable that neither difficulty nor disappointment could make the least impression on him; and he never abandoned the pursuit of any object until he had obtained a satisfactory acquaintance with it. Unfortunately, however, the methods he made use of in preparing his objects for the microscope are now entirely unknown.

For dissecting *small insects*, Swammerdam had a brass table, to which were attached two brass arms, movable at pleasure. The upper part of each of these vertical arms was constructed in such a manner as to have a slow vertical motion, by which means the operator could readily alter their height. One of these arms was to hold the minute objects, and the other to apply the microscope.

The lenses for Swammerdam's microscopes were of various sizes as well as foci. His observations were always begun with the smallest magnifiers, from which he proceeded by progressive steps to the greatest.

The minute scales or feathers which cover the wings of moths or butterflies afford very beautiful objects for the microscope. Those from one part of the wing frequently differ in shape from such as are taken from other parts; and near the thorax, shoulder, and on the fringes of the wings, we generally meet with hair instead of scales. The whole may be brushed off the wing, upon a piece of paper, by means of a camel's hair pencil; after which the hairs can be separated, with the assistance of a common magnifying glass.

Great difficulty is experienced in dissecting properly the proboscis of insects, such as that of the gnat, and the experiment must be repeated a great number of times before the structure and situation of the parts can be thoroughly investigated, as the observer will frequently discover in one what he could not in another. The *collector of the bee*, which forms an exceedingly curious object, ought to be carefully washed in spirit of turpentine, by which means it will be freed from the unctuous matter adhering to it: when dry, it is again to be washed with a camel's hair pencil, to disengage and bring forward the small hairs which form part of its microscopic beauty. The best method of preparing the stings of insects, which are in danger of being broken from their hardness, is to soak the case and the rest of the apparatus for some time in spirit of wine, or turpentine; then lay them on a piece of paper, and with a blunt knife draw out the sting, holding the sheath with the nail of the finger, or any other blunt instrument; but great care is necessary to preserve the feelers, which, when cleaned, add much to the beauty of the object. The *beard* of the lepas antifera is to be soaked in clean soft water, frequently brushing it, while wet, with a camel's hair pencil: after it is dried, the brushing must be repeated, with a dry pencil, to disengage and separate the hairs, which are apt to adhere together.

The eyes of insects in general form very beautiful and curious objects. Those of the libellula and other flies, as well as of the lobster, &c., must be cleaned from the blood, &c., after which they should be soaked in water for some days: one or two skins are then to be separated from the eye, which would be otherwise too opaque and confused, but some care is requisite in this operation; for, if the skin be rendered too thin, it is impossible to form a proper idea of the organization of the part. In some substances, however, the organization is such that by altering the texture of the part we destroy the objects which we wish to observe. Of this sort are the nerves, tendons, and muscular fibres, many of which are viewed to most advantage when floating in some transparent fluid. Thus very few of the muscular fibres can be discovered when we attempt to view them in the open air, though great numbers may be seen if they be placed in water or oil. By viewing the thread of a ligament in this manner, we find it composed of a vast number of smooth round threads lying close together. Elastic objects should be pulled or stretched out while they are under the microscope, that the texture and nature of those parts the figure of which is altered by being thus extended may be more fully discovered.

To examine bones by the microscope, they should first be viewed as opaque objects; but afterwards, by procuring thin slices of them, they may be viewed as transparent. The sections should be cut in all directions, and well washed and cleaned; and, in some cases, maceration will be useful, or the bones may be heated to a high temperature, in a clear fire, which will render the bony cells more conspicuous.

MIDWIFERY is the art of aiding and facilitating childbirth, and of providing for the preservation of the health and life of the mother during and after her delivery. It is founded on physiological and pathological science. Midwifery, in some form, has been employed from the most ancient times, even among the rudest nations, although it was at first very defective, and consisted, probably, only in the most obvious and indispensable manual applications and aids. Even in the most cultivated nations of antiquity, this art was in a low state. The Israelites had their midwives. The first accounts of scientific male midwifery are to be found among the Greeks of the age of Hippocrates, who died 357 B. C. From the writings of that period, we learn that the obstetrical art had

then reached a higher degree of cultivation among the Greeks than in most parts of Europe during the last century. There was, notwithstanding, much that was wrong and injudicious in their system, and only a small part of the proper means of assistance was made use of. They often contented themselves with invoking Ilithyia, the goddess of childbirth. Among the Romans, midwifery was confined to a few simple aids, and sacrificing to Juno Lucina, and other deities who presided over childbirth. It was not till a later period that the Roman women commonly employed midwives; but, in difficult cases, the physicians were called in. These were either Greeks living in Rome, under the dominion of the Roman emperors, or they drew their knowledge chiefly from Greek authors. To this epoch belong particularly Soranus, and Moschion, who composed the first manual of midwifery which has come down to us.

In the middle ages, the science was very much neglected: it was confined to the cutting of the fœtus from the body of the mother, in case of her death before delivery. In consequence of the injudicious interference of the popes, who conferred the professorships in the newly-established schools on the monks, and gave them the privilege of practising physic, while they strictly prohibited the practice of surgery and anatomy both to the physicians and laity (1215), the obstetric art became confined to internal and superstitious applications, and, indeed, generally sunk into the hands of women, monks, peasants, and other ignorant persons. When they had exhausted their medical skill, the saints were invoked, images and relics were hung upon the woman in labour, &c. The art continued in this state till the sixteenth century. At this time, the improvements in printing and engraving gradually introduced a better era, since the surviving works of the Greeks, Romans, and Arabians were multiplied, the intellectual intercourse among men became more general, and the spirit of enquiry was awakened and found a wider field. At this period, the business of midwifery was so exclusively in the hands of women that it was disgraceful for a man to engage in it. Such an undertaking was considered as an abominable attempt on the virtue and honour of the female sex, and he who ventured upon it as little better than a monster. In Hamburg, in 1521, Veites was condemned for this offence to the flames. Several books, however, were published for the better instruction of midwives in their profession. The first was by Eucharius Roslein, at Worms, called the *Rose-Garden for Midwives and pregnant Women* (1513). The science of anatomy, which was now more freely studied and patronized, also contributed much to the improvement of midwifery, in which Vesalius, in Padua (1543), particularly distinguished himself. The physicians and surgeons turned their attention only to the theoretical part of the science, but the latter gradually proceeded to the practice of it, by performing the Cæsarean operation on women who had died in childbirth (which was now not only permitted but commanded by law), and gradually undertaking other operations on women pregnant and in labour.

Francis Rousset, a surgeon in Paris, published a treatise, in 1581, in which he brought several proofs of the possibility of safely performing the Cæsarean operation on the living mother, and it was he who first gave this operation its present name. After the publication of this treatise, the operation was frequently performed on the living subject, both in and out of France, and sometimes even when it was not unavoidably necessary. Pineau, a surgeon in Paris, first suggested, in 1589, the section of the pubes, by the observations which he communicated on the separation which takes place between the bones of the pelvis, for the purpose of facilitating birth, when made difficult by the extreme narrowness of the pelvis.

In Germany, midwifery long remained in an imperfect state: the midwives were generally ignorant, and men were seldom employed; while in France and Italy it was already a common thing to call in the aid of physicians and surgeons. A surgeon named Clement, distinguished in the practice of midwifery, and who had attended La Valiere, the mistress of Louis XIV., in her delivery, first received the name of *accoucheur* as a title of honour. The surgeons were so well pleased with the name that they gradually adopted it as a general appellation. Henry of Deventer, a surgeon of Holland, was the first who, in 1701, endeavoured to establish midwifery on scientific principles. In France, where the art had risen to higher perfection than in other countries, a school for midwives was established in the *Hôtel Dieu*, in 1745.

The history of the origin and invention of the forceps, that highly useful instrument in midwifery, is involved in some obscurity. Between 1660 and 1670, Chamberlin, a London surgeon, professed to have invented an instrument with which he was able to terminate the most difficult labours without injuring either the mother or child: but he kept this discovery to himself, and in 1688 went to Amsterdam, where he sold it to certain practitioners, who turned it to their profit. It was thus kept secret among certain persons for a long time. At last, Palfyn, a famous anatomist and surgeon, of Ghent, in Flanders, acquired some knowledge of the instrument, and caused one to be made in 1723. Some species of forceps appear to have been known even in the time of Hippocrates; but the merit of Chamberlin's invention consisted in making the blades separable, and capable of being locked together after having been introduced into the vagina, and placed one on each side of the head of the child. It was afterwards very much improved, especially by Levret, in 1747; Plevier, in Amsterdam, 1750; and Smellie, in London, 1752. The art of midwifery was also perfected by the writings and instructions of these men. Germany, too, produced several men of eminence in this department of the medical art, who were not only famous for their operative skill, but contributed much to the advancement of midwifery by their observations, and to the diffusion of correct principles on the subject by their lectures and writings. The establishment of several schools of midwifery also facilitated the study of the art, and brought it to the degree of perfection which it now boasts. The course now adopted seems to be the true one, viz. by the cultivation of all the branches of knowledge connected with this department, to determine the cases in which art may and ought to be passive and leave the work to nature, and those in which nature is insufficient to accomplish the delivery alone, or, at least, without injury to the mother or child.

Military Schools and Academies; schools in which soldiers receive instruction, or in which youths are educated for the army. Among the former are the *soldier-schools*, in which, as is the case in many

armies, particularly in the Prussian, the private soldiers learn reading, writing, and arithmetic; they are also, in the last-named country at least, often instructed in singing; so that it is common, in the Prussian army, for a battalion to have its choir, which sings during divine service, and on other occasions. Instruction has become so general in the Prussian army, by means of regimental and battalion schools, that during the last years of peace the army was considered an institution for the instruction of the whole country, as every Prussian is obliged to serve for a short time in the standing army. In some armies *conversazioni* have been introduced, in which the officers hold discourse with the sergeants and privates on subjects connected with the service. When the officers in the armies of the European continent were taken from the nobility only, academies were established by government to educate young noblemen. They were called in Germany *Ritterakademien*, and sometimes were of a high character. These establishments must be distinguished from the *cadet-houses*, so called, where, generally speaking, the children of officers only are educated for the army. In many countries noblemen only are admitted into these also. In several French cities companies of *cadets* existed when Louis XV., in 1751, first established an *école royale militaire* for 500 young noblemen, from eight to eleven years old. The principal features of its organization have been retained in most similar institutions.—See *Recueil d'Edits Déclarations, Reglemens et Ordonnances du Roi, concernant l'Hôtel de l'Ecole roy. militaire* (Paris, 1762). The (so called) *Ritterakademien* originated later. Frederic the Great established the *école militaire* at Berlin for the further accomplishment of young officers. Even before the seven years' war, every French city in which a regiment of artillery was garrisoned had its artillery school. Saxony followed in 1766, Austria and Prussia later. At present, the two latter have excellent artillery schools, as well as others in the department of engineering. Since 1815, the standard of scientific education of officers has been much raised in several armies; in none, however, so high as in the Prussian, in which no person can be promoted without a severe examination. Besides the regimental schools in this army, mentioned above, every division has its school, to which young sergeants, &c., are admitted (if they appear, on examination, to possess the necessary elementary knowledge), in order to prepare themselves for examination for a lieutenancy. Mathematics, history, geography, statistics, the applied mathematics, modern languages (particularly French), and the military sciences, are here the chief subjects of study. The artillery corps and engineer corps have their separate schools for young officers to prepare themselves for examination for the rank of captain. The captain must continue his studies by himself, to stand an examination for the rank of major. Of the troops of the line, every regiment is allowed to send a few of its young officers, who must have shown great diligence, talent, and considerable acquirements, to the general military school in Berlin—an institution of a very high character. Here the highest branches of mathematics, geology and mineralogy, chemistry and natural philosophy, history, politics, the military sciences, languages, &c., are taught in a course which occupies three years. The officers also attend such lectures in the university as they choose. It is evident how much such establishments must raise the standard of learning in the whole army; and, indeed, the corps of officers contains some of the most accomplished men in Prussia. In France, the former cadet-houses have been called, since the revolution, *military schools*. (For the system of military education pursued in this country, see WOOLWICH ACADEMY.)

MILITARY SCIENCES have, by some of the latest writers, been divided into the following heads:—

1. *Tactics*, or the science of the drilling of an army, as well as of disposing and directing it in battle, requiring, of course, an acquaintance with the different kinds of arms. The artillerist devotes himself particularly to the ordnance, and the various branches of science requisite for its proper management. The lower, or elementary tactics, treats of the drilling and formation of soldiers, and accustoming them to the movements of small and large divisions, and varies in character with the different regulations of different armies. Tactics proper treats of the mode of disposing troops in the actual combat, and of the peculiar use of each species of force, cavalry, infantry both heavy and light, and artillery. With them is nearly connected the choice of camps, or castrametation, though, since the introduction of the system of requisition, this branch of military science has gone almost entirely out of use. The knowledge of the employment of pontons seems also to fall within this department.

2. *Strategy*, the science of forming the plans of operation, and of directing armies accordingly. It has been but lately treated as an independent branch, since Von Bulow wrote on the subject. Many military writers will not as yet admit such a division; but little doubt can exist that it will be universally adopted.

3. The branch which treats of the just understanding and proper use of the surface of the earth for military purposes. The tactics of our time can overcome a number of obstacles, arising from the character of the ground, which were formerly considered insurmountable; still, however, this department of military science, embracing, as it does, a knowledge of the usual character of the ground under given circumstances, the course of rivers, of mountains, valleys, geological formations, &c., remains indispensable for a useful officer. To this branch belongs, or, at least, with it is intimately connected, reconnoitring, surveying, drawing of topographical maps, &c.

4. *Military Architecture*, or *Fortification*, which teaches how to fortify any given point by artificial means, so that a few persons may be able to defend themselves against the attacks of many. It embraces the construction of proper fortresses, the attack and defence of fortified places, and the knowledge of field fortification, which treats of the construction, attack, and defence of redoubts in the field, raised for transitory purposes, and not so solid as in standing fortifications.

5. *Military History and Biography*, which embraces a knowledge of all important wars, and also of the various organizations of armies, the principles upon which war has been carried on, the different arms used, and the consequences attending their use, &c.; also the lives of the greatest generals, and the resources which they found in situations where many leaders would have despaired. The history of military literature, to a certain extent, is indispensable for a young officer, that he may be directed to

the best works of the different nations. Of the auxiliary sciences, the most important is mathematics, which is indispensable for a scientific soldier; military geography, embracing a knowledge of roads, rivers, valleys, &c., the law of nations, modern languages, and gymnastics. The branches of study now enumerated are more or less essential to the well-educated soldier; but they cannot make a general, any more than the study of the thorough base can make a Mozart, or the knowledge of perspective, anatomy, and colours, a Raphael. Although it would be a useless waste of time to set about proving that scientific study is essential to a commander, yet the greatest general must find the most important resources in his own genius; and this must act with unfailing promptness. An artist, if unsuccessful, may renew his efforts; but in war the issue of a battle may depend upon an instant decision, and a failure is ruin.

Militia, in the modern adaptation of the word, a body of armed citizens regularly trained, though not in constant service in time of peace, and thereby contradistinguished from *standing armies*. It includes all classes of the citizens, with certain exceptions, who are drilled at particular periods in peace, and liable, according to certain laws, to march in cases of emergency against the enemy, in some countries, however, not beyond the frontier. The regular organization of the militia distinguishes it from the *levée-en-masse*.

The militia exists in different countries under different names; in some countries, they are denominated *burgher-guards;* in Austria and Prussia, *landwehr* (defence of the country); while the *levée-en-masse* is called in these two countries *landsturm*. When the feudal system had rendered almost every nobleman on the European continent an independent monarch in miniature, he kept his own warriors in his castle or territory, and the difficulty of assembling a large general army, even for a good purpose, was immense. In the cities, where a more republican spirit prevailed, all the citizens were obliged, at least, to take part in the defence of their city,—a duty which they were not seldom called upon to perform. The introduction of standing armies, chiefly in consequence of the endeavour of monarchs to render their governments more and more independent of the nation at large, caused the citizens to take less and less share in the military service, and in many cases excluded them from it entirely; yet while in some countries the services of the citizen soldiers were becoming every day of less importance, so that burgher-militia even became a term of contempt in many places, other governments began to foster the national militia. The Swedish army was, at an early period, a kind of general militia. The army consisted of twenty-one regiments, of which each owner of landed property was bound to maintain one man. They assembled every year for three weeks, and during this time, as well as in war, received full pay (as is now the case in Prussia). The Danish army was formed on a somewhat similar plan, about a third of each regiment consisting of enlisted foreigners, while two-thirds were Danish subjects, who, like those in Sweden, were supported by the owners of landed property, but, in return, were obliged to assist the latter in the cultivation of their estates. In Germany, similar plans were adopted. The privates and non-commissioned officers of the militia followed their agricultural or mechanical pursuits, and were generally under the command of officers out of active service. They were obliged to serve only within the country. Frederic the Great used them to garrison the fortresses: the same was the case with the Austrian militia during the war of succession. The bad organization and unmilitary spirit of these troops rendered them the butt of the troops of the line. In some cases, it was even considered allowable, by the laws of war, not to give them any quarter, when they were employed out of the limits of their country, and were taken prisoners.

The militia of this country is somewhat differently organized. The origin of this national force is generally traced back to Alfred. The feudal military tenures succeeded; and although the personal service which this system required degenerated by degrees into pecuniary commutations, or aids, the defence of the kingdom was provided for by laws requiring the general arming of the citizens. Under Edward III., it was provided that no man should be compelled to go out of the kingdom at any rate, nor out of his shire except in cases of urgent necessity, nor should provide soldiers unless by consent of parliament. We first find lord-lieutenants of counties, whose duty was to keep the counties in military order, mentioned as known officers in the fifth year of Philip and Mary. When Charles I. had, during his northern expeditions, issued commissions of lieutenancy, and exerted certain military powers, which, having been long exercised, were thought by one party to belong to the crown, it became a question in the long parliament how far the power over the militia did inherently reside in the king, which, after long agitation, ended by the two houses denying the crown this prerogative, and taking into their own hands the entire power over the militia. After the restoration, when the military tenures were abolished, the sole right of the crown to govern and command the militia was recognized.

The most characteristic features of our militia at present are, that a number of persons in each county are drawn by lot, and officered by the lord-lieutenants and other principal land-owners, under a commission from the crown. When drawn out, they are subject to military law. In all cases of actual invasion, or imminent danger thereof, and in all cases of rebellion or insurrection, the king may embody the militia, and direct them to be led into any part of the kingdom, having communicated the occasion to parliament, if sitting, or, if not sitting, having declared it in council, and notified it by proclamation.

In Tyrol, a general arming against the French was effected in 1799. When, in 1808, the arch-duke Charles was placed at the head of military affairs, a general *landwehr* was organized throughout the Austrian provinces. In 1809 these troops fought well. They amounted at that time to 300,000 men; after 1811 to only 71,500; but after 1813 the *landwehr* was again placed on its old footing, and part of it have since been called out to increase the army intended to overawe the Italian States. In Hungary, the common law obliges every nobleman to serve himself, and to bring his vassals into the field, if called upon. This *levée* is called an "insurrection of the nobility." In 1809 this insurrection consisted of 17,000 horse and 21,000 foot.

In 1807 a general militia was organized in Russia,

which in 1812 was of considerable service against the French. Prussia has carried the *landwehr* to greater perfection than any other country; in that country the militia forms the main body of the army. In 1813 every male person under forty-eight years of age was obliged to serve against the French in the militia. The national militia, at that time, included both infantry and cavalry. The lower commissioned officers were elected by the militia-men, and the higher by the estates of each circle. When Napoleon returned from Elba, Prussia had 150,000 infantry and 20,000 cavalry of the militia under arms. After the peace of 1815, the *landwehr* was established on its present footing. Every Prussian, with the single exception of mediatized princes, is obliged to serve for three years in the standing army, between his seventeenth and twenty-third year. Part of this time, however, he is generally on furlough. If a person equips himself and undergoes an examination, by which he proves that he has received a certain education, he has to serve one year only in the standing army. After this time, every Prussian belongs, until his thirtieth year, to the first class of the *landwehr*, attends frequent drills on Sunday afternoons, and has to serve for three weeks every year, when the *landwehr* is called together foı great manœuvres. Every man is in the *landwehr* what he was in the standing army—foot-soldier, horseman, or artillerist. Government hires horses for the time of manœuvring, and, as they are well fed and ridden by experienced men, the owners generally like to let out their horses for the occasion. Every Prussian, from his thirtieth year until his fortieth, belongs to the second class of militia. This is not called together in time of peace, and, in war, only in time of the greatest emergency, and then only for local or provincial service. Thus Prussia is enabled to assemble a very large army in proportion to its population, whether to the injury of the nation is a question not to be discussed here.

In regard to the militia of the United States of America, it was provided, by act of congress of 1792, that "all able-bodied white male citizens, between the age of eighteen and forty-five, with certain exceptions (officers of government, members of congress, mariners in service, &c.), shall be enrolled in the militia. The persons so enrolled are to provide themselves with the common arms of infantry, and with ball cartridges, &c., at their own expense. These are arranged into brigades, regiments, companies, &c., as the legislatures of the several states may direct. Each battalion is to have at least one company of grenadiers, light-infantry, or riflemen, and each division at least one company of artillery and one troop of horse. Proper ordnance and field artillery are to be provided by the government of the American states. The cavalry and artillery troops are to consist of volunteers from the militia at large, not exceeding one company to each regiment, and are to equip themselves, with the exception of the ordnance above mentioned. Whenever the United States of America are in danger of actual invasion from any foreign nation or Indian tribe, the president is authorized to call forth such number of the militia of the state or states most convenient to the scene of action as he may judge necessary. In case of an insurrection in any state against the state government, he may, on application from the legislature of such state (or from the executive, when the legislature cannot be convened), call forth such number of the militia of any other state or states as may be applied for, or as he may judge necessary to suppress the insurrection."

MILK; a secretion peculiar to the females of the class *mammalia*, or those animals which feed their young from their teats, and which takes place, in some of them, only during and after the time of gestation. It differs as procured from different animals, but its general properties are the same in all. When this fluid is allowed to stand for some time, it undergoes spontaneous changes, and is resolved into its component parts: a thick yellowish substance collects on the surface, which is *cream*, while the milk beneath becomes thinner than before, and is of a pale bluish colour. When cream is kept for some days without being disturbed, it gradually becomes thicker, till at last it acquires the consistence of cheese; so that one method of making cream-cheese is merely by putting cream into a linen bag, and leaving it there till it becomes solid. When cream is shaken, it is resolved into its component parts. The process by which this is accomplished is called *churning*, by which two substances are obtained, *butter* and *butter-milk*. In the making of butter, cream is allowed to stand for some time, during which an acid is generated. It is then put into a churn and shaken, by which the butter is gradually separated. What is left (the butter-milk) has a sour taste, but by no means so much so as that of the cream before the churning. Butter is sometimes also made from cream which has not become sour, but the process is much more tedious, the acid formed in the other case favouring its separation. Butter is merely an animal oil, solid at a natural heat, but held in solution in milk by some of the other substances. As thus procured, it is not pure, but may in a great measure be freed from its impurities by washing it with cold water; and, though apt to become rancid, yet, when mixed with salt, may be kept any length of time. Milk from which butter has been taken undergoes spontaneous changes. It becomes much sourer, and congeals into a mass of the consistence of jelly. When heated, the fermentation of this coagulum is hastened, and by the addition of certain substances it very soon takes place; thus acids and spirit of wine curdle it, which is owing to the albumen it contains being acted on by them, in the same way as blood or white of eggs. By far the most powerful coagulator, however, is the substance called *rennet*, which is the decoction of the stomach of animals, as a calf. When the milk is previously heated, and rennet added, it is almost instantly coagulated. If after this it is cut, a thinnish fluid oozes from it, and, if it is put into a bag and squeezed, the whole of this is forced out, and a whitish tough matter is left; the former is *whey*, the latter *curd*. On this depends the process of making cheese, which varies in richness according to the mode followed in preparing it. When milk is heated gradually, and merely to the temperature at which it curdles, and the curd freed gently from the whey, it retains almost the whole of the cream, which adds to its richness and flavour. But when it is curdled quickly, and the whey is speedily removed by cutting the curd, a great deal or nearly the whole of the cream is carried off, and the cheese is poor, and has not the rich flavour of that made in the other way. The latter is the method generally followed in Scotland, where both cheese and butter are obtained from milk, the

whey procured in the process yielding a considerable quantity of the latter; and hence the comparative poorness of Scottish cheese. In making cheese, having obtained the curd, and freed it from its whey, the remaining part of the process is merely to subject it to pressure, by which the whole of the whey is forced out, the colour being communicated by the addition of colouring matter: that generally used is annotta, which is mixed with the milk. Whey has a pleasant taste, and contains a considerable quantity of a sweetish substance, called *sugar of milk;* hence it is frequently used as drink, and, from its nutritious quality, it is administered to delicate people; hence also the use of asses' milk, which contains a large quantity of it. It is from its containing this saccharine matter that it is sometimes, as in some of the northern parts of Europe, made to undergo fermentation, by which a very weak spirituous fluid is obtained. By evaporation it affords a minute quantity of saline matter, and a considerable portion of sugar of milk. When whey or milk is exposed to a temperature between 60° and 80° it undergoes a spontaneous change, attended by the production of an acid, which was originally examined by Scheele, and has been termed *lactic acid.*

Mill-stone; the stone by which corn is ground. The mill-stones which we find preserved from ancient times are all small, and very different from those in use at present. Thoresby mentions two or three such found in England, among other Roman antiquities, which were about twenty inches broad; and there is good reason to believe that the Romans, as well as the Egyptians and Jews, did not employ horses, or wind, or water, as we do, to turn their mills, but made their slaves and captives do this laborious work.

In a very picturesque part of Germany, on the banks of the Rhine, and at about five leagues lower down than Coblentz, are situated the very extensive mill-stone quarries of Nieder Mending. They were discovered and opened by the Romans, who long extracted from them stones for the hand-mills, which formed an indispensable part of the equipment of a Roman army. Since then they have been constantly worked more or less; for even the wild hordes of our Saxon ancestors, who also spread over this part of Germany, destroying the dominions of the Romans and avenging their slaughtered and conquered countrymen, were acquainted with the means of grinding corn and bruising malt, and contrived to extract mill-stones from the Roman quarries. At present they are worked to a great extent, and not only supply all the neighbourhood, but are sent down the Rhine into Holland, in great numbers, whence they are again further exported to England, and to the West and East Indies. The sending them down the river forms one great branch of the commerce which is carried on by all the little towns and villages situated on the Rhine in this vicinity, though the little town of Andernach is its principal seat. The mode of conveyance is not expensive, the stones being merely laid on some of the immense rafts of timber which are annually floated down the Rhine, from the upper part of Germany, to supply the industrious Dutchmen with boats, ships, and houses. Numerous small rafts, which come down the little rivers that are lost in the course of the Rhine, are united at Andernach into one great floating forest, and thence, carrying along with it many travellers, as well as a great number of people necessary to manage it, and various heavy substances, the produce of Germany, this forest descends into Holland, to be again broken up and distributed, and, when converted into ships, destined to bear the produce of one quarter of the globe to the other.

The principal quarries are situated in a plain called *Hacher*, about half a mile from the village of Nieder Mending. They are seven in number, about fifty feet deep each, and employ a great many hands: while some are raising the ponderous stones to the surface by means of cranes and wheels, others are cutting them, a third class are piling them up, and a fourth are loading the vehicles which are to carry them away. An opening is made into all these quarries in the same manner, which is curious, not only in itself, but from the long time it has been practised. The strata from which the mill-stones are cut lies fifty feet below the surface, and it is difficult to imagine how it was first discovered. To arrive at it a shaft is sunk of the shape of an inverted cone, or of a funnel, being twenty-five feet in diameter at the top, eleven or twelve feet diameter at the bottom, and fifty feet deep. Around the sides a very narrow spiral path is made, by which the workmen descend, and even children run down and up for their amusement. It is customary for five or six families to unite their labours to sink such a shaft, and with time and much hard work they are thus enabled to reach the stones, which are the means of supplying them with both meat and clothing. The earth through which they have to dig is formed partly of gravel and partly of large masses of a compact lava, which, however, it requires no very extraordinary force to break through. Arrived at the depth of fifty feet, a hard, blackish, heavy stone is met with, full of small, but regular pores, which gives a few sparks when struck with steel, but is not at the same time so hard but that the workmen can fashion it to their will, with strong and well-tempered tools. Mineralogists describe this stone as a sort of lava, or like the melted mass which flows down burning mountains, and suppose it to have been produced by those subterraneous fires which once perhaps were the means of effecting a great change over all the surface of the globe, and which still exist in various places. They suppose that it extends at least all over the plain already mentioned; but, never having as yet been dug through, its thickness has not been ascertained. Were this stone solid throughout its whole extent, it would have been nearly impossible to work it; but, on cooling, it had separated into numerous masses of a prismatic form, which enable the labourers to interpose wedges or levers, and break off pieces large enough to make mill-stones of five or six feet in diameter. So many of these have now been taken away that immense galleries have been cleared out, which, separated from each other by the prismatic columns left standing to support the roof, like stalactites in an artificial cavern, have a resemblance to the most ancient of our Gothic cathedrals. Every thing in them seems vast and grand, except the beings so insignificant in appearance at the side of these enormous pillars, by whose labours, however, they have been brought to light, and can be crumbled to dust.

Mill-stones have been made so large in this country that the centrifugal force which results from their rotatory motion has been known to tear them asunder. The ancient mill-stones, on the contrary, where so small that they could readily be carried by a single individual.

The mill-stones employed in Tuscany differ from those used in this country: indeed, on account of their great superiority of form, it may be advisable to describe them somewhat in detail. The size of the mill-stone used for the most powerful mills, as well as for those of inferior strength, is a circle of four feet; the size of the eye is about seven inches. The face of the upper stone is hollowed to a conical surface, the depth or height being about one-inch and a half. The face of the lower stone is convex; the surface is nearly a portion of a sphere, having a radius of thirty feet, so that a distance of about an inch is left between the centre of the two faces. A deep socket is let into the upper stone, or runner, for the reception of the iron nut, placed on the square of the spindle. The runner is balanced, and rendered parallel to the convex or bed stone, by means of four small wooden wedges, two on each side, between the nut and the socket.

They profess to cut the teeth in the form of the hyperbolic spiral; but, being cut without any great regard to mathematical precision, they are usually portions of circles, the place of whose centres are in the circumference of a circle of fourteen inches radius, described from the centre of the stone. In general, the teeth are as close as possible to each other; but near the eye they are fewer, deeper, and coarser.

The tool employed to cut the teeth is a double edge hammer, four inches wide, very sharp, and weighing about 12lbs. When the stones are new from the quarry, a few days are sufficient for this operation: and, when they have been already in use, any able miller's man will complete it in twenty minutes. The real grinding surface is the six or eight inches next the circumference of the stone.

The flour produced varies in colour, according to the nature of the stones employed.

When the upper stone, or runner, is made of diallage rock, consisting of crystals of diallage imbedded in nearly compact felspar (both of which are so soft as to yield without much difficulty to the knife, and yet always preserve a sufficient degree of roughness, even after long-continued friction), the face of the stone being made perpendicular to the plane of the bed of the rock, and the bed, or lower stone, made of a compact porcellanous limestone, of a pale flesh colour, softer than the diallage rock, the stones are applied to the grinding of the finer wheat, the combination of the hard and soft stone being well adapted to grind the central parts of the grain into fine flour, leaving the bran broad and clean; and it is difficult, even by coarse sifting, to give a brown tinge to bread made of this flour.

When both stones are made of a granular talcase quartz, with garnet imbedded in it, the mill is used for grinding the coarser and harder kinds of corn. These stones grind almost the whole of the grain exposed to their action; so that the quantity of bran that remains after sifting is extremely small; hence this mode of grinding is essentially economical. However carefully the flour produced by these mills may be sifted, the bread it produces, although very wholesome and agreeable, is always dark-coloured, and sometimes almost a black.

This system of grinding used in Italy differs greatly from that of the English millers, and possesses considerable advantages over our method.

In England the hardest French buhrs are used for both stones; the grinding surfaces are flat and parallel to each other, and the teeth in right lines: hence the grinding is partly performed by rubbing, and partly by cutting, so that the bran is more or less torn, and part of it, being ground as fine as the flour itself, is not separable by dressing or bolting, and injures the colour. The friction of the stones also excites considerable heat, so that the meal comes out warm to the touch, and is sometimes so much heated as to be incapable of making light bread.

In Italy, for fine flour, hard and soft stones being combined, the difficulty is overcome much more readily, since white flour is produced by means of the same dressing which, when applied to two hard stones, produces brown flour. The upper stone is far from hard, and the lower is still softer; the teeth are very shallow, but their form is such as to impel the grain towards the circumference, where the distance between the stones is continually lessening, so that the grain appears to be ground by friction, without any cutting of the bran, especially as the corn is soft, from its dampness; hence the flour is not liable to be overheated, and, the bran being separated almost wholly by the first sieve, the flour is pure.

Mill-Work. Under this head we purpose noticing the simplest combinations of wheel work which are employed in the construction of mills, and, under the articles Wind and Water Mills, complete views, both graphic and descriptive, will be given of their construction.

The business of a millwright is usually combined with the practical part of engineering, and much of the wind and water power formerly employed in giving motion to machinery is now superseded by the introduction of the steam-engine. Indeed, without the agency of steam-power, this country could in no shape compete with other manufacturing nations; so that, on account of the great importance of the steam-engine as a prime mover, it will be advisable to devote a commensurate space to its illustration.

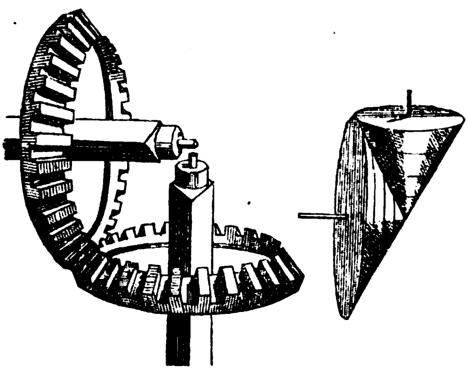
Various are the methods by which motion may be communicated from one part of a machine to another; and much of the skill of the millwright consists in his adapting certain methods to his particular purposes. Sometimes a simple cord, or a cord with pulleys, may be used. Levers, either simple or combined, are employed to communicate and also change the direction of the motion. Rods also are employed, which may be carried to a great distance by being connected together. But, of all the methods of communicating motion, that by means of wheels is the most frequent. Wheels may be made to turn each other even by the simple contact of their surfaces when pressed together; or their circumferences may be formed into brushes with short thick hair, which enable them to turn each other with considerable force; or they may have cords, or straps of leather, or chains, passing from one to another; and at other times there are points or protuberances on the rims of the wheels. The most usual method, however, of making wheels drive each other is by means of teeth. These are either cut into the substance of which the wheel is composed, when it is of metal; or formed at the same time as the rest of the wheel, when it is cast.

The proper method of shaping the teeth of wheels, so as to communicate the motion equally, and with as little friction as possible, is a matter of very great nicety, and has given rise to much study among mechanics. The ends of the teeth should be curves,

but not parts of complete circles. They may be formed of the curve called the epicycloid; or of the involutes of circles, which are curves described by a point of a thread which has been wound round the wheel while it is uncoiled.

A wheel which has teeth cut upon the circumferences, so as to project out in the plane of its face, is called a spur wheel; and, when the projection of the teeth is at right angles to the face of the wheel and parallel to the axis, the wheel is called a crown or contrate wheel. Sometimes the faces of the two wheels are in the same plane, and consequently the axes parallel; and at other times the axes are at right angles to each other, one being a spur and the other a contrate wheel.

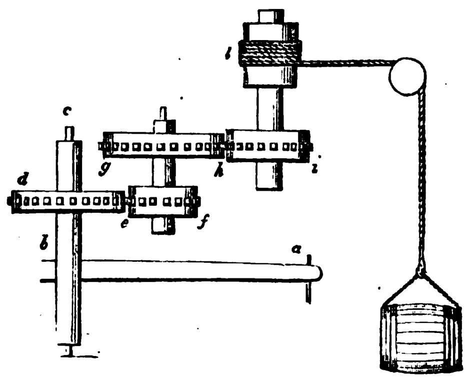
There is a mode of placing the teeth frequently resorted to, which consists in levelling the edge of the wheel, and cutting the teeth on the bevel, by which they may turn in each other, though variously inclined, and the teeth have also great strength. Their principle consists in two cones rolling on the surface of each other, as in the accompanying small engraving; if their bases are equal, they will perform their revolutions in one and the same time.



If the cones are fluted, or have teeth cut in them diverging from the centre, they are then called *bevel geer*. The teeth may be made of any dimension, according to the strength required; and it is of great use to communicate a motion in any direction, or to any part of a building. The bevel geer represented in the left-hand figure must be supported by a frame at the point where the pivots intersect each other. The frame is usually formed of iron or wood, and when the latter is employed the pivot-hole is of brass. The perpendicular shaft should always be made to revolve on a sharp point in the centre.

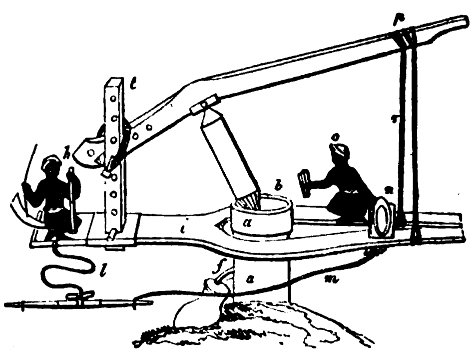
Hook's universal Joint, described under that article, may be applied to communicate motion instead of bevel geer, where the speed is to be continued the same, and where the angle does not exceed thirty or forty degrees and the equality of motion is not regarded; for, as it recedes from a right line, its motion becomes very irregular. This joint may be constructed by a cross, or with four pins fastened at right angles upon the circumference of a hoop, or solid ball. It is of great use in cotton mills, where the tumbling shafts are continued to a distance from the moving power.

The employment of animal power in the simplest species of mill-work may be well illustrated by the accompanying sketch, in which a horse may be attached to a long lever, and thus made to raise a weight by a train of wheels and pinions.



The weight to be raised is suspended by a rope or chain which winds round the drum *l*. On the same axis is placed a wheel, *i*, actuated by another wheel, *g h*. The wheel *d e* gives motion to the whole by the intervention of the small wheel at *f*. A horse at *a* may be considered as the prime mover, as the lever *a b* is on the axis *c*. Now, in this apparatus, there is a loss of power, but a gain in velocity.

The various modes of constructing mills for domestic as well as manufacturing processes will be explained hereafter, and we now purpose confining ourselves to a single example of the mode of employing animal power in a way which, from its simplicity, might be adopted to a great extent in this country. There is a mill of a cheap and effective kind used in many parts of the East, which appears to have suggested the use of the ordinary snuff-mill. Indeed, it is, in some respects, superior to it. This mill, which is employed in the preparation of sugar, consists of a mortar, beam, lever, pestle, and regulator, as represented in the engraving beneath:—



The mortar, *a a*, is a tree about ten feet long, and fourteen inches over, which is sunk in the earth, so as to leave about two feet above ground. At the top is formed a conical cavity like a funnel, which ends in a hollow cylinder, with a hemispherical projection at the bottom, in order to allow the juice to run freely to the small opening that conveys it to a spout, *f*,

from which it runs into an earthen pot. Round the upper mouth of the mortar is a circular cavity, *b*, which serves to collect any of the juice that may run over from the upper end of the pieces of cane. A channel is cut to convey this juice down the outside of the mortar to the spout, *f*.

The beam, *i*, is about 16 feet long, and six inches thick, and is cut from any large tree that is divided by a fork into two arms A hollow circle is made in the fork for the mortar, round which the beam turns horizontally: the surface of this excavation is secured by a semicircle of some strong wood; the other end of the fork is left quite open, in order that the beam may be changed without any trouble. The bullock driver sits on the undivided end, to which the cattle are yoked by a rope, *l*, from his end of the beam; and they are kept in the circular tread by another rope, *m*, which passes from the yoke to the forked end of the beam. A basket, *n*, is placed upon the forks to hold the cuttings of the cane, and the man, *o*, who feeds the mill, sits between this basket and the mortar. He takes care to place the pieces of cane sloping down the cavity of the mortar, just at the time that the pestle comes round; and, after the pestle has passed, he removes those which have been squeezed.

The lever, *p*, is a piece of timber nearly as long as the beam. The thickest end, which is also the lowest, is connected with the undivided end of the beam by means of a regulator, *t*. A little way from the place where it is joined to the regulator, a piece of very hard wood is morticed into the lower side of the lever, and a smooth conical hollow is made in this piece, to receive the head of the pestle. The end of the lever furthest from the regulator is fastened by two ropes to the two arms of the beam.

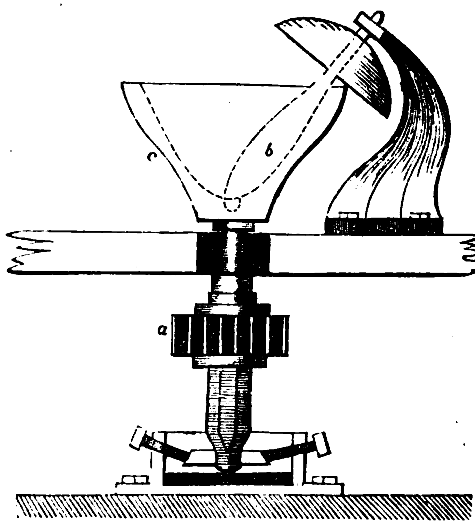
The pestle is a strong cylindrical piece of timber, cut to a point at each end. The upper end is a smooth cone, the lower end a piramid of twelve to fifteen sides, at the point of which is a short cylinder. As the pestle is placed obliquely, it rubs strongly against the sides of the mortar as it passes round; and its cylindrical point rubs also on the top of the hemispherical projection, *d*, which is in the bottom of the cavity of the mortar.

The regulator, *t*, is a strong square of timber, which passes through the undivided end of the beam, and is secured below it by part of its circumference being left for cheeks. It is pierced by eight holes, and a pin is placed in the lowest hole, to prevent the regulator from falling when the strain is removed.

The canes with which the mill is supplied are cut into pieces, six inches long. The mill goes night and day during crop time, and presses about fifty-six pots or 218 gallons of juice in that time. Two bullocks are used at a time, and, as they are driven very fast, they are changed every time three pots of juice are expressed, and work no more that day.

In the manufacture of snuff in this country, the grinding is performed by a loaded pestle, made to turn round as it rubs against the sides of a cast-iron mortar, the pointed lower end of the pestle being retained in its place by a hole at the bottom of the mortar. In large manufactories, a number of these mortars are placed in a circle, having a large toothed wheel in the centre, surrounded by as many upright spindles with pinions to work in the wheel.

Mr. Gill has proposed an improvement on this plan, which is represented beneath.



The mortar, *c*, is in this arrangement made to revolve, and the pestle, *b*, is supported by a bracket firmly attached to the beam beneath. The pinion, *a*, rests on a conical axis, and communicates, as in the old arrangement, with the principal driving wheel.

Water-mills are of three kinds:—*breast-mills*, *undershot-mills*, and *overshot-mills*, according to the manner in which the water is applied to the great wheel. In the first, the water falls down upon the wheel at right angles to the *float-boards*, or bucket, placed to receive it. In the second, which is used where there is no fall of water, the stream strikes the float-boards at the lower part of the wheel. In the third, the water is poured over the top, and is received in buckets arranged round the wheel.

A less quantity of water will turn an overshot-mill (in which the wheel has buckets instead of float-boards) than a breast-mill, where the fall of water seldom exceeds half the height of the wheel; so that, when there is but a small quantity of water, and a fall great enough for the wheel to lie under it, the bucket, or overshot-wheel, is always used: but, where there is a large body of water with a small fall, the breast or float-board must be used. Where the water runs only upon a small declivity, it can act but slowly upon the under part of the wheel, in which case the motion of the wheel will be slow; and therefore the floats ought to be very long, that a large surface of water may act upon them, so that what is wanting in velocity may be made up in power; and then the cog-wheel may have a greater number of cogs in proportion to the rounds in the trundle, in order to give the mill-stone a sufficient degree of velocity.

It was the opinion of Smeaton that the powers necessary to produce the same effect on an undershot-wheel, a breast-wheel, and an overshot-wheel, must be to each other as the numbers 2.4, 1.75, and 1.

Wind, which we may consider as the next substitute for animal power, appears to have been first employed to give motion to machinery in the beginning of the sixth century. The use of this species of

mechanical force is however principally limited to the grinding of corn, the pressing of seed, and other simple manipulations, the great irregularity of this element precluding its application to those processes which require a continued motion.

A windmill with four sails, measuring seventy feet from the extremity of one sail to that of the opposite one, each being six feet and a half in width, is capable of raising 926 lbs. 232 feet in a minute, and of working on an average eight hours per day. This is equivalent to the work of thirty-four men, twenty-five square feet of canvass performing the average work of a day labourer. A mill of this magnitude seldom requires the attention of more than two men; and it will thus be seen that, making allowance for its irregularity, wind possesses a decided superiority over every species of animal labour.

The following very important errors have frequently been made by mathematicians and practical mechanics, in the estimation of the force of the wind or the water on oblique surfaces; they have generally arisen from inattention to the distinction between pressure and mechanical power. It may be demonstrated that the greatest possible pressure of the wind or water, on a given oblique surface at rest, tending to turn it in a direction perpendicular to that of the wind, is obtained when the surface forms an angle of about 55° with the wind; but that the mechanical power of such a pressure, which is to be estimated from a combination of its intensity with the velocity of the surface, may be increased without limit by increasing the angle of inclination, and consequently the velocity. The utmost effect that could be thus obtained would be equal to that of the same wind or stream acting on the float-boards of an undershot-wheel: but, since in all practical cases the velocity is limited, the effect will be somewhat smaller than this: for example, if the mere velocity of the sails or float-boards be supposed equal to that of the wind, the mechanical power will be more than four-fifths as great as that of an undershot-wheel; that is, in the case of a windmill, more than four-fifths of the utmost effect that can be obtained from the wind. In such a case Maclaurin has shown that the sails ought to make an angle of 74° with the direction of the wind: but in practice it is found most advantageous to make the angle somewhat greater than this, the velocity of the extremities of the sails being usually, according to Mr. Smeaton, more than twice as great as that of the wind. It appears, therefore, that the oblique sails of the common windmill are in their nature almost as well calculated to make the best use of any hydraulic force as an undershot-wheel; and, since they act without intermission throughout their whole revolution, they have a decided advantage over such machines as require the sails or fans to be exposed to a more limited stream of the wind during one half only of their motion, which is necessary in the horizontal windmill, where a screen is employed for covering them while they are moving in a direction contrary to that of the wind: and such machines, according to Smeaton, are found to perform little more than one-tenth of the work of those which are more usually employed. The sails of a common windmill are frequently made to change their situation according to the direction of the wind, by means of a small wheel with sails of the same kind, which turns round whenever the wind strikes on either side of it, and drives a pinion turning the whole machinery; the sails are sometimes made to furl or unfurl themselves according to the velocity of the wind, by means of a revolving pendulum, which rises to a greater or less height, in order to prevent the injury which the flour would suffer from too great a rapidity in the motion, or any other accidents which might happen in a mill of a different nature. The inclination of the axis of a windmill to the horizon is principally intended to allow room for the action of the wind at the lower part, where it would be weakened if the sails came too nearly in contact with the building, as they must do if they were perfectly upright. When it is necessary to stop the motion of a windmill, a break is applied to the surface of a large wheel, so that its friction operates with a considerable mechanical advantage.—*Partington's Scientific Gazette.*

MINA, among the Greeks; a weight of a hundred drachmæ: also a piece of money valued at a hundred drachmæ; sixty of them were equivalent to a talent.

MINARET; a round tower, generally surrounded with balconies, and erected near the mosques in Mohammedan countries, from which the *muezzin* summons the people to prayer, and announces the hours, bells, as is well known, not being in use among the Mohammedans. (See MOSQUE.)

MINE, in *military language;* a subterraneous passage dug under the wall or rampart of a fortification, or under any building or other object, for the purpose of blowing it up with gunpowder. The gunpowder is in a box, and the place where the powder is lodged is called the *chamber* (in French, *forneau*). The passage leading to the powder is termed the *gallery;* the line drawn from the centre of the chamber perpendicularly to the nearest surface of the ground is called the *line of least resistance.* It has been found, by experience, that the figure produced by the explosion is a paraboloid, and that the centre of the powder, or charge, occupies the *focus.* The pit or hole made by springing the mine is called the *excavation.* The fire is communicated to the mines by a pipe, or hose, made of coarse cloth, whose diameter is about 1½ inch, called a *saucisson* (for the filling of which nearly half a pound of powder is allowed to every foot), extending from the chamber to the entrance of the gallery, to the end of which is fixed a match, that the miner who sets fire to it may have time to retire before it reaches the chamber. The saucisson is laid in a small trough, called an *augut,* to prevent it from contracting any dampness. This is made of boards. The mine of a fortress is called a *countermine,* the gallery of which runs under the covered way along the outer margin of the fosse. From this, ramifications, called *rameaux,* extend under the glacis, from which again little passages are made on both sides, to afford means for listening to and finding out the enemy's subterraneous movements. If the powder is lodged so deep under ground that its explosion is not perceptible on the surface, it yet shakes the ground all around, and destroys the hostile mines in the neighbourhood. This is the *globe de compression,* invented by Belidor.

The miners are often armed with short weapons, as pistols and cutlasses, in order to defend themselves, if they meet a hostile mine. The mines are often so long that it is necessary to convey fresh air by artificial means to the most advanced workmen,

and those who are faint are passed back from one to the other; the same is done with the dead, if a combat ensues below. Frequently, also, balls, made of all kinds of substances which produce an offensive smoke, are lighted, in order to stop the enemy, provided the mine permits the party who leave the ball an easy retreat. Sometimes mines are dug in the field, with a view of blowing up such of the enemy as can be allured to the spot. In such case, a small body of men must generally be placed there, in order to induce the enemy to attack them; these are sometimes sacrificed with the enemy.

Mining; the process for obtaining minerals from the bowels of the earth. Mines are vast underground works, furnished with galleries which frequently extend for miles from the entrance of the shaft or well. Light is constantly procured from artificial sources, and in some mines the dull glimmer of the "Davy lamp" is the only substitute for the cheerful rays of the sun. Vegetation assumes a new character, so that plants lose their colour, and in most cases their ordinary flavour. The miner is at one time exposed to an atmosphere which forbids any thing like healthful respiration, and at another the destructive fire blast comes on the wings of the wind ready charged for his destruction. The best means of averting these dangers will be found under our articles Ventilation and Safety Lamp. The minerals are found in veins, strata, or lumps, and contain gold, silver, platina, quicksilver, lead, iron, copper, tin, zinc, calamine, bismuth, cobalt, arsenic, manganese, antimony, molybdena, and other metallic substances; also sulphur, brown-coal, pit-coal, bitumen, alum, and all combinations of sulphuric acid with metallic bases. The mines are generally denominated from the substances obtained from them; for instance, gold, silver, iron, lead, coal, alum, salt mines, &c. We must distinguish, 1. the mines in primitive mountains: 2. those in flœtz mountains; 3. those in alluvions. Of the first sort the most important are the following:—

1. The mines in the Cordilleras in Spanish America. There are few regions so remarkable for their richness in minerals as this chain of mountains. The most important mines are those of silver; yet there are also several gold, quicksilver, copper, and lead mines. In Chili, especially in the province of Coquimbo, are several silver and some important copper mines. The richness of the silver mines of Potosi (Buenos Ayres) may be judged of from the fact that more than 1300,000,000 of dollars have been coined there since the year 1545; but the ores are now poor. Copper, lead, and tin are also found in Buenos Ayres, the last, however, in beds of sand or clay, from which it is obtained by washing. On the opposite side of the chain, in a low plain, are the silver mines of Guantajaya, famous for the large lumps of solid silver which they formerly furnished, and of which one weighed 800 lbs. In Peru, there are forty districts particularly celebrated for their gold and silver mines. Gold is found especially in the provinces of Guailas and Pataz, and silver in the districts of Guantajaya, Pasco, and Chota. The mines of Pasco, which twenty years ago produced more than two millions of dollars yearly, had been, like most of those of South America, very negligently managed, till, in 1816, miners from Cornwall began to work them by means of steam-engines.

The mines of the province of Chota now furnish about 42,000 lbs. troy of silver every year. The quicksilver mine of Guancavelica, in Peru, is the only one of this kind in the new world. In the province of Guantajaya, rock-salt mines are also found. North of the province of Chota, the Cordilleras are not so rich in metals.

In New Grenada there are several silver mines; at Aroa, in Caraccas, a copper mine exists, which yields 1600 cwt. of metal yearly; and at Santa Fe rock-salt and pit-coal are found. Although Mexico contains various metals, very little except silver has been obtained from that country. Almost all the mines are situated in the Cordilleras, and consist of 3000 pits, which comprise from 4000 to 5000 beds or layers.

The only mine in Mexico in which pumps of any kind had been tried prior to the late introduction of machinery from England is that of Moran, in the district of Rëal del Monte; of which M. Humboldt gives the following account:—

The mountains of the district of mines of Rëal del Monte contain beds of porphyry, which, with respect to their relative antiquity, differ a good deal from one another. The rock which forms the roof and the wall of the argentiferous veins is a decomposed porphyry, of which the base sometimes appears clayey, and sometimes analogous to splintery hornstone. The presence of hornblende is frequently announced merely by greenish stains, intermingled with common and vitreous feldspar. At very great elevations (for example, in the beautiful forests of oak and pine of Oyamel), we find porphyries with a base of pearl-stone containing lobsidian in layers and nodules.

What relation exists between these last beds, which several distinguished mineralogists consider as volcanic productions, and the porphyries of Pachuca, Rëal del Monte, and Moran, in which nature has deposited enormous masses of sulphuret of silver and argentiferous pyrites. This problem, which is one of the most difficult in geology, will be resolved only when a great number of zealous and intelligent travellers shall have gone over the Mexican Cordilleras, and carefully studied the immense variety of porphyries which are destitute of quartz, and which abound both in hornblende and vitreous feldspar.

The district of mines of Rëal del Monte does not display (as at Friberg in Saxony, Derbyshire in England, or the mountains of Zimapan and Tasco in New Spain) a great number of rich veins of small size, on a small tract of ground. It rather resembles the Hartz and Scheminitz mountains, in Europe, or those of Guanaxuato and Potosi, in America, of which the riches are contained in a few mineral depositions of very considerable dimensions. The four veins of Biscaina, Rosario, Cabrera, and Encino, run through the districts of Rëal del Monte, from Moran, and Pachuca, at extraordinary distances, without changing their direction, and almost without coming in contact with other veins which traverse or derange them.

The Veta de la Biscaina, of less considerable dimensions, but perhaps still richer than the vein of Guanaxuato, was successfully wrought from the beginning of the sixteenth to the eighteenth century. In 1726, and 1727, the two mines of Biscaina and Xacal still produced together 333,969 ounces of silver. The great quantity of water which filtrated through the

crevices of the porphyritic rock, joined to the imperfection of the means of drawing it off, compelled the miners to abandon the works when they were yet only sixty-five fathoms in depth. A very enterprising individual, Don Joseph Alexandro Bustamente, was courageous enough to undertake a level near Moran; but he died before completing this great work, which is 7715 feet in length from its mouth to the point where it crosses the vein de la Biscaina. The level of Moran traverses the vein de la Biscaina, in the San Ramon shaft, at a depth of 115 fathoms below the level of the surface on which the whims are placed. The profit of the proprietors has been annually diminishing since 1774. In place of driving levels for trial, to discover the vein on a great extent, they continued their sinking to a depth of nearly fifty-three fathoms below the level. At that depth the vein preserved its great wealth in sulphuret of silver mixed with native silver; but the abundance of water increased to such a degree that twenty-eight whims, each of which required more than forty horses, were not sufficient to draw it off. In 1783, the weekly expenses amounted to 1875*l.* After the death of the old Count de Regla, the works were suspended till 1791, when the proprietors ventured to re-establish all the whims. The expense of these machines, which drew up the water, not by means of pumps, but by bags suspended by ropes, then amounted to more than 31,252*l.* per annum. At length they reached the deepest point of the mine, which, according to accurate measurement, is only 1064 feet above the level of the lake of Zumpango; but the ore which they extracted did not compensate the expense of the process, and the mine was again abandoned in 1801.

It is surprising that they never thought of substituting foı this wretched plan of drawing off the water by bags proper pump apparatus, put in motion by horse whims, by hydraulic wheels, or by machines moved by a column of water (colonne d'eau). A level begun at Pachuca, or lower down towards Gazare in the valley of Mexico, would have exhausted the mine of Biscaina at the pit of San Ramon, for a depth of 202 fathoms. The same object could be obtained at less expense by following the project of M. D'Elluyar, in placing the mouth of a new level near Omitlan, in the road which leads from Moran to the place of amalgamation at Regla. This last level, before reaching 12,466 feet in length, would cut the vein of Biscaina.

The plan which is at present followed is to leave off the clearing of the old works, and to investigate the mineral repository in points where it has never yet been worked, and this is effected by boring. In studying at Reäl del Monte the surface and undulations of the ground, we observe that the vein of Biscaina has furnished for three centuries its greatest riches from a single spot; that is to say, from a natural hollow contained between the shafts of Delores, Joya, Santa Cayetano, San Teresa, and Guadaloupe.

The mines of Moran, formerly of great celebrity, were abandoned for forty years on account of the abundance of water, which could not be drawn off. In this district of mines, which is near the mouth of the great level of Biscaina, there was placed in 1801 a machine *à collonne d'eau,* of which the cylinder is ten feet three inches in height, and six feet nine inches in diameter. This machine, the first of the kind ever constructed in America, is much superior to those of the mines of Hungary. It was executed agreeably to the calculations and plans of M. del Rio, professor of mineralogy in Mexico, who has visited the most celebrated mines of Europe, and who possesses at once the most solid and most various acquirements. The merit of the execution is due to M. Lachansee, a Brabant artist of great talents, who has also fitted up for the school of mines of Mexico a very remarkable collection of models, for the use of students in mechanics and hydrodynamics. It is to be regretted that this fine machine, in which the regulator of the suckers is put in motion by a particular mechanism, was placed in a situation where there is great difficulty in procuring a sufficiency of water to keep it going. M. Humboldt says that, when he was at Moran, the pumps could work only three hours a day. The construction of the machine and the aqueducts cost 10,937*l.* sterling: they did not at first calculate on more than half the expense, and they imagined the mass of water to be very considerable; but, the year in which the water was measured being exceedingly rainy, it was believed to be much more abundant than it actually was.

The benefits described as being conferred on the mining districts by putting their industry in motion were thus justly anticipated in the report of Don Lucas Alaman, minister for foreign affairs, dated November 1, 1828.

"It is a principle admitted by all writers on political economy that the most direct encouragement which can be given to agriculture and to industry is to facilitate the consumption of the produce of the one and the sale of the manufactures of the other. If the mines be considered amongst us under this point of view, it will be found that nothing contributes so much as they do to the prosperity of those essential branches of the public riches. The great number of people that are occupied in them, the animals that are employed in the working of the machinery and in transporting the ores, the consumption that arises therefrom of grain, as well as of soap, paper, iron, &c., give a powerful impulse to agriculture, the arts, and to commerce. If practical illustration be necessary to prove those facts which are doubted only by men whose minds are pre-occupied by the paradoxical assertions of systematic economists, they may be found on a comparison of the state of our mining provinces, such as Guanaxuato and Zacatecas, previous to the year 1810 and at the present period. Abundance and prosperity then reigned throughout both of them. The agriculturist found in those famous reales (districts) a ready and certain market for his produce; the smith, the carpenter, the mason, a constant employment for his industry; the merchant an extensive consumption for the goods which he introduced; and the treasures drawn from the bowels of the earth were distributed throughout, and revivified the most distant provinces, in payment for the soap, wood, salt, magistral, horses, and mules, that were brought from all parts. The nature of our ores is also a powerful cause of these happy results: they are generally poor in metal, and most abundant in quantity, and require for their manufacture a great quantity of machinery and ingredients; and it may therefore be said that the miner merely draws forth funds to distribute them freely among the labourers, merchants, and artisans; and we must naturally conclude that the prosperity of these classes depends principally upon the impulse given to them by the

mines, which in our notion are thus the acting principle of all the other branches of industry."

In America gold is principally obtained by washing. The principal gold-washings are on the western side of the Cordilleras; in New Grenada, from the province of Barbacoa to the isthmus of Panama; in Chili and on the shores of the Gulf of California; or on the eastern side in the upper valleys of the Amazon. The washings of New Grenada also furnish platina.

2. The mines of Hungary, including those of Transylvania, and of the Bannat of Temeswar, compose four great districts:—*a*. the north-western, which includes the mines of Schemnitz, Kremnitz, Kœnigsberg, Neusohl, Schmœlnitz, Bethler, Rosenau, &c., which chiefly furnish gold, silver, copper, lead, &c.;—*b*. the north-eastern, containing the mines of Nagybanya, Kapnick, Felsœbanya, Wizbanya, Olaposbanya, and Olapos, which all yield gold, besides the mines of Marmarosch, which furnish great quantities of iron;—*c*. the eastern district, in which the mines of Nagyag, Korosbanya, Vœrœspatak, Boitza, Csertesch, Fatzsbay, Almas, Porkura, Botschum, and Stonischa, deserve notice, which chiefly furnish gold and copper; near Vayda-Huniad and Gyalar are important iron-mines;—*d*. the south-western district, or the mines of the Bannat of Temeswar, yield silver and copper in Oravitza, Moldawa, Szaska, and Dognaczka; while in Dombrawa, and Ruchersberg, iron, quicksilver, and cobalt, are obtained. Hungary contains also mines of pit-coal and rock-salt, the latter especially on the banks of the Danube, the Marmarosch, and the Nera. The whole produce of Hungary amounts to 3250 lbs. troy of gold, 53,125 lbs. troy of silver, from 36,000 to 40,000 cwt. of copper, 8000 cwt. of lead, and about 60,000 cwt. of iron.

The interior of an Hungarian mine, of which a view is given in the above engraving, differs very much from that of the mines in this country. Vast chasms provided with inclined planes take the place of the shafts and galleries in our underground works.

Dr. Clarke thus describes his descent of the Presburg mine, his visit to which was made after he had personally inspected many of the principal works of the same nature in other countries, and especially in his own:—

"As we drew near to the wide and open abyss, a vast and sudden prospect of yawning caverns, and of prodigious machinery, prepared us for the descent. We approached the edge of the dreadful gulf whence the ore is raised, and ventured to look down, standing upon the verge of a sort of platform, constructed over it in such a manner as to command a view into the great opening, as far as the eye could reach amidst its gloomy depths; for to the sight it is bottomless. Immense buckets, suspended by rattling chains, were passing up and down; and we could perceive ladders scaling all the inward precipices, upon which the work-people, reduced by their distance to pigmies in size, were ascending and descending. Far below the utmost of these figures, a deep and gaping gulf, the mouth of the lowermost pit, was, by its darkness, rendered impervious to view. From the spot where we stood, down to the place where the buckets are filled, the distance might be about seventy-five fathoms; and, as soon as any of these buckets emerged from the gloomy cavity we have mentioned, or until they entered it in their descent, they were visible, but beyond this point they were hid in darkness.

"The clanking of chains, the groaning of the pumps, the hallooing of the miners, the creaking of the blocks and wheels, the trampling of horses, the beating of the hammers, and the loud and frequent subterraneous thunder from the blasting of the rocks by gunpowder in the midst of all this scene of excavation and uproar, produced an effect which no stranger could behold unmoved: we descended, with two miners and our interpreter, into this abyss. The ladders, instead of being placed like those in our Cornish mines upon a series of platforms, as so many landing-places, are lashed together in one unbroken line, extending many fathoms, and warped so as to suit the inclination or curvature of the sides of the precipices: they are not always perpendicular, but hang over in such a manner that, even if a person held fast by his hands, if his feet should happen to slip, they would fly off from the rock and leave him suspended over the gulf; yet such ladders are the only means of access to the works below,—and, as the labourers are not accustomed to receive strangers, they neither use the precautions, nor offer the assistance, usually afforded in more frequented mines. In the principal *tin* mines of Cornwall, the staves of the ladders are alternate bars of wood and iron: here they were of wood only, and in some parts rotten and broken, making us often wish, during our descent, that we had never undertaken an exploit so hazardous. In addition to the danger to be apprehended from the damaged state of the ladders, the staves were covered with ice or mud, and thus rendered so cold and slippery that we could have no dependence upon our benumbed fingers, if our feet failed us. Then, to complete our apprehensions, as we mentioned this to the miners, they said, —'Have a care! It was just so,' talking about the staves, 'that one of our women fell, about four years ago, as she was descending to her work.' 'Fell!' said our Swedish interpreter, rather simply, 'and

pray what became of her?' 'Became of her!' continued the foremost of our guides, disengaging one of his hands from the ladder, and slapping it against his thigh, as if to illustrate the manner of the catastrophe,—'*she became* (pantaker) a pancake.'

"As we descended further from the surface, large masses of ice appeared, covering the sides of the precipices. Ice is raised in the buckets with the ore and rubble of the mine: it was also accumulated in such quantity in some of the lower chambers that there are places where it is fifteen fathoms thick, and no change of temperature above prevents its increase."

This seems to militate against a notion now prevailing, that the temperature of the air in mines increases directly as the depth from the surface, owing to the increasing temperature of the earth under the same circumstances and in the same ratio; but it is explained by the width of the aperture at the mouth of the mine, which admits a free passage of atmospheric air. In our *Cornish* mines, ice would not be preserved in a solid state at any considerable depth from the surface.

"After much fatigue, and no small share or apprehension, we at length reached the bottom of the mine. Here we had no sooner arrived than our conductors, taking each of us by an arm, hurried us along, through regions of 'thick-ribbed ice' and darkness, into a vaulted level, through which we were to pass into the principal chamber of the mine. The noise of the countless hammers, all in vehement action, increased as we crept along this level; until, at length, subduing every other sound, we could no longer hear each other speak, notwithstanding our utmost efforts. At this moment we were ushered into a prodigious cavern, whence the sound proceeded; and here, amidst falling waters, tumbling rocks, steam, ice, and gunpowder, about fifty miners were in the very height of their employment. The magnitude of the cavern, over all parts of which their labours were going on, was alone sufficient to prove that iron ore is not deposited in veins, but in beds. Above, below, on every side, and in every nook of this fearful dungeon, glimmering tapers disclosed the grim and anxious countenances of the miners. They were now driving bolts of iron into the rocks, to bore cavities for the gunpowder, for blasting. Scarcely had we recovered from the stupefaction occasioned by our first introduction into this *Pandemonium*, when we beheld, close to us, hags more horrible than perhaps it is possible for any other female figures to exhibit, holding their dim quivering tapers to our faces, and bellowing in our ears. One of the same sisterhood, snatching a lighted splinter of deal, darted to the spot where we stood, with eyes inflamed and distilling rheum,—her hair clotted with mud; and such a face, and such hideous yells, as it is impossible to describe,"

> "Black it stood as night—fierce as ten furies—
> Terrible as hell!"

This description, though poetical, is of the greatest value, as coming from the pen of one of the most acute observers who have yet written on the subject.

3. The mines of the Altai mountains are very important; they constitute the districts of Kolyvan, Zmeof, Tcherepanofsky, Smenofsky, Nikolaisky, Philipofsky, &c., with a yearly produce of upwards of 1875 lbs. troy of gold, 37,500 lbs. troy of silver, and a considerable quantity of copper, iron, and lead.

4. The mines of the Ural are dispersed, at different distances, around Ekaterinburg; those of Tourinsky produce about 20,000, and those of Goumechefsky 40,000 cwt. of copper yearly. The iron, which is obtained in the regions of Balgodat and Keskanar, amounts to more than 1,000,000 cwt. yearly. Near Berezov 312 lbs. troy of gold were formerly produced; but the quantity is now far more considerable.

5. The mines of the Vosges and the Schwarzwald (Black Forest). In the former, nothing but iron is found; in the latter, silver, at Badenweiler, Hochberg, and Wolfach, amounting to 1125 lbs. troy; at the first of these places, moreover, 800 cwt. of lead are obtained yearly, and at Wittichen, cobalt; besides iron in different places.

6. The mines of the Hartz: *a.* the silver, lead, and copper mines, &c., of the Upper Hartz, in the environs of the mining towns of Clausthal, Zellerfeld, Lautenthal, Wildemann, Grund, and Andreasberg; *b.* gold, silver, and copper mines, near Goslar; *c.* copper mines in the neighbourhood of Lauterberg; *d.* iron mines at Lauterberg, Walkenried, Elbingeroda, and Blankenburg; *e.* silver, lead, and iron mines, in the vicinity of Magdesprung: annual produce about 6¼ lbs. troy of gold, 18,750 lbs. troy of silver, 2000 cwt. of copper, 50,000 cwt. of lead, 30,000 cwt. of litharge, 200,000 cwt. of iron.

7. Mines in the eastern part of Germany:—*a.* in the Saxon Erzgebirge, at the towns of Freiberg, Marienberg, Annaberg, Ehrenfriedersdorf, Johanngeorgenstadt, Schneeberg, annually yielding about 32,500 lbs. troy of silver; at Altenberg, Geyer, Ehrenfriedersdorf, Zinnwald, annually from 3000 to 4000 cwt. of tin; at Schneeberg, annually 8000 cwt. of cobalt, 600 cwt. of copper, 80,000 of iron;—*b.* in Bohemia: silver, at Joachimsthal, Mies, Przibram, &c., 13,800 marcs (8625 lbs. troy); tin, at Schakenwald, &c., 2000 cwt.; cobalt, 4000 cwt.; lead, 1800 cwt.; iron, 190,000 cwt.;—*c.* in the Fichtelgebirge, principally iron, annually about 50,000 cwt.;—*d.* in Moravia, at Iglau, &c., 3125 lbs. troy of silver; *e.* in the Riesengebirge, at Jauer, Kupferberg, Reichenstein, 330 cwt. of copper, 560 cwt. of smalt; 1900 cwt. of arsenic, 1200 cwt. of sulphur, 20,000 cwt. of vitriol.

8. Mines in the middle and north-western parts of France. Those at Villefort, in the department of the Lozère, yield 2000 cwt. of lead and 1000 lbs. troy of silver; at Poullaouen and Huelgoat, in Bretagne, 10,000 cwt. of lead, 1250 lbs. troy of silver.

9. Mines of Scandinavia. Norway produces 1600 marcs (1000 lbs. troy) of silver; at Kongsberg, in 1768, 25,000 lbs. troy, 7200 cwt. of copper, 140,000 cwt. of iron, 4000 cwt. of smalt, 10,000 cwt. of alum; Sweden, 1875 lbs. troy of silver, from 18,000 to 20,000 cwt. of copper, 1,500,000 cwt. of iron.

10. Mines of the Pyrenees: these are insignificant, and iron only need be mentioned.

11. Mines of the Alps: they are not, by any means, proportioned to the immense masses of those mountains; the silver mines of Allemont, in Dauphiné, annually produce 2000 marcs (1250 lbs. troy); the iron mines of Allevard, in the department of the Isere, and the lead and silver mines of Pesey, in Savoy, formerly produced 4000 cwt. of lead, and 1562 lbs. troy of silver annually; the iron mines of Cogna and Traverselle, in Piedmont, annually yield upwards of 200,000 cwt. of iron; the copper mines at Falkenstein and Schwarz, in the Tyrol, formerly

were of importance; the gold mines at Gastein and Muerwinkel, in Saltzburg, annually yield 118 marcs (74 lbs. troy) of gold; the iron mines in Saltzburg and the Tyrol annually produce from 60,000 to 70,000 cwt.; the iron mines in Styria 450,000 cwt.; those in Carinthia 260,000 cwt., and those in Carniola 100,000 cwt.; the copper mines at Schladming in Styria, at Kirschdorf in Carinthia, at Agardo in the territory of Venice, and at Zamabor in Croatia, furnish copper containing silver; the zinc mines at Raibel, in Carinthia, annually produce 3400 cwt.; the lead mines at Villach and Bleiberg, &c., about 50,000 cwt.; the quicksilver mines at Idria, about 1500 cwt.; the rock-salt mines, at Hallein, Berchtesgaden, Aussee, Ischel, Hallstadt, &c., upwards of 3,000,000 cwt. of salt.

12. Mines of the countries bordering on the Rhine, and of the Ardennes. Copper is obtained from the mines of Rheinbreitenbach and Dillenburg, about 1200 cwt. yearly; lead and silver, from the mines of Holzapfel, Pfingstwiese, Læwenburg, Augstbach, Ehrenthal; of the former, 12,000 cwt.; of the latter, 2187 lbs. troy; iron of an excellent quality, and in great quantity, is procured in the Stahlberg, in the environs of the town of Siegen, on the banks of the Lahn and Sayn, at Hohenkirchen in Hesse, on the Hundsrück, in the Eifel, in the territories of Luxemburg, &c., calamine in the vicinity of Limburg, in the Netherlands, 15,000 cwt. yearly; in the neighbourhood of Aix-la-Chapelle, from 30,000 to 40,000 cwt.; in the county of Mark, 2600 cwt.; lead, at Vedrin, not far from Namur, 4000 cwt., together with 437 lbs. troy of silver.

The mines of other countries may be thus briefly noticed:—The environs of Nertschinskoi, in Siberia, are very rich in useful minerals, and yield from 18,750 to 21,750 lbs. troy of silver.

The mineral wealth of Spain and Portugal is now almost exhausted; the quicksilver mines of Almaden formerly furnished 20,000 cwt. yearly; the lead and copper mines are still productive, yielding annually more than 100,000 cwt. There are copper mines in Japan, China, Persia, Arabia, in Tartary, in the islands of the Indian Sea, in Barbary, Morocco, Abyssinia, &c.; tin is produced in China, Pegu, the peninsula of Malacca, Sumatra, Banca, &c., in the latter country alone, 70,000 cwt.: zinc is said to be abundant in India; quicksilver in China and Japan; Brazil furnishes 17,500 lbs. troy of gold yearly, which is more than is obtained from any other country; Africa at least 4375 lbs. troy, and Southern Asia at least 1250 lbs. troy yearly. The island of Elba contains a great deal of iron.—

The mines in Flœtz mountains are highly important: above all, the coal mines—this country alone furnishing 400,000,000 cwt.; France, 20,000,000; the Netherlands and the countries along the Rhine, 62,000,000; Silesia, 6,000,000; Saxony, 1,200,000; Austria, 680,000; Bavaria, 320,000; Hanover, with the rest of Germany, 6,000,000. The lead mines in the vicinity of Aix-la-Chapelle, which annually furnish from 14,000 to 16,000 cwt. of lead and upwards of 20,000 cwt. of lead ore, called *alquifou*, used for glazing earthenware, are in Flœtz mountains; also the copper mines in the territories of Mansfeld, at Frankenberg, Bieber, and Riegelsdorf, in Hesse, the former yielding 10,000 cwt. of copper and 5000 lbs. troy of silver; the important iron mines on the Stahlberg, in the Hessian seignory of Schmalkalden; the lead mines at Tarnowitz, in Upper Silesia, annually yielding 5300 cwt. of lead and 937 lbs. troy of silver; the calamine and zinc mines, in upper Silesia and Poland, which annually afford 80,000 cwt. of calamine and 25,000 cwt. of zinc.

We may now turn more particularly to the progress of mining in our own island, more especially as regards Devonshire, Cornwall, and North Wales. Our mines, though of such great national importance, have as yet attracted but little attention from any but those immediately concerned in them, and near the places in which they are situated; it is the more to be wished that men of science would address themselves to the consideration of their management as those engaged in them are not often men of sufficient ability, or science, to strike out any material improvements. To be a good miner requires an active mind, with industry and strict observation; these should be accompanied by some general knowledge, at least, of practical mineralogy, chemistry, mechanics, hydraulics, &c., and such a knowledge of principles as might lead to improvements in the mechanical parts of his business. It would be unreasonable to expect to find these qualifications general, but the attention of men of science would not fail to point out to the practical miner the improvements of which his operations are susceptible.

On the continent, many of the most eminent men have not thought it beneath them to undertake the management of mines; and to this it is fair to ascribe the success with which many of them have been conducted. In our own country, the superintendence of men of science during the last few years has been attended with very considerable advantage, and has given to this species of property a new, important, and improved stimulus.

The tin of Britain was known in distant parts of the world at a very remote period. It is generally believed that the Phœnicians were the nation principally engaged in trading with Britain for this article. Tin works were carried on, long before iron was known in this country: many tools of oak are now found, which tradition, among the miners, make to have belonged to the Saxons and Danes.

It is asserted that the greatest quantity of tin was formerly found in the forest of Dartmoor, in the county of Devon; and works to a vast extent must have been carried on there, if it be true, as we are told, that 30,000 men found employment upon this tract. It is, however, to be considered that by the ancient mode of working, without the aid of machinery, many more hands must have been found necessary than at present, probably in the proportion of three to one. All these works at Dartmoor were only on or near the surface: now, however, the lodes or veins of tin found in this district are not valuable enough, or do not continue to a sufficient depth to make them profitable to work.

Almost all the tin procured in former ages was probably from stream works, in bottoms or low grounds, where fagments of the ore, washed from the lodes in the neighbouring hills, subside, and are separated from the earth in a granular form by washing. This, of course, is obtained without any subterranean work. In such situations as these, it is probable that metals were first discovered, mixed merely with the upper soil, or lodging in clefts of rocks.

The tracing and following lodes of ores into the earth is a more difficult task than coming to the me-

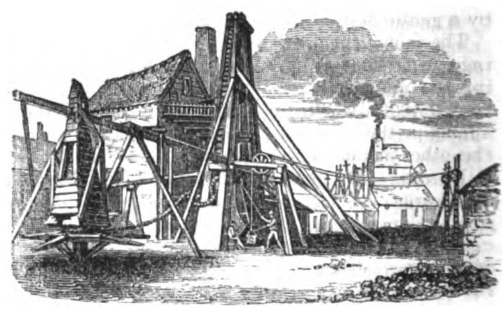
tal in the way of stream works; it requires more energy of mind, and a more advanced state of the arts. The difficulty that must attend keeping a mine, sunk to some depth, free from water, by manual labour only, could not but prevent miners, before the application of machinery, from sinking low into the bowels of the earth. We have, however, some instances in Cornwall, where old workings are met with at so great a depth as to be even now with difficulty kept dry by means of machinery; but these, though they may be accounted ancient, were probably opened long subsequent to the origin of mining in this country.

There are many mines which could not possibly be worked without the aid of gunpowder, and, until the discovery of this powerful agent, under-ground operations must have been both uncertain and difficult. The hammer and wedges for metals were probably the first materials for splitting rocks (and they still continue, in the ground that will yield to them, to be used both in Cornwall and Wales), and the pick, or instrument for clearing the ground, having a head for driving the wedges, called by the miners *gads*, from the Cornish word *gedn*, a wedge. The form of these instruments, found in old works, afford evidences of their antiquity. Wedges of dry wood were also very ingeniously made use of, by driving them in the clefts, and then wetting them, so as to cause them to swell, and cleave the rocks asunder. Fire was an agent long since employed in splitting the rocks; but the effects of gunpowder so far exceeded every thing before made use of, for such purposes, that its discovery and application to works of this kind form a grand epoch in the history of mining. This, it appears, took place in Hungary, or Germany, about the year 1620, and was first introduced into England at the copper mine at Ecton, in Staffordshire, about the year 1670, by German miners, brought over by Prince Rupert; but it was not in use in Somersetshire till 1684, after which, probably, the Cornish miners became acquainted with this powerful assistant to their operations.

Tin was the first object of enquiry by the miners of Cornwall. It was probably first found on the surface of the ground; almost all the low grounds in Cornwall bear the marks of having been *streamed*. The Romans probably interested themselves in the working of the mines; indeed, one principal inducement to that people's turning their attention to this island seems to have been the metals that were reputed to be found here. The Saxons neglected these hidden treasures, but the Normans worked them to great advantage. From that time to the end of the reign of John, the mines were not profitable, and mostly in the hands of the Jews. They revived in the time of Richard; but in the reign of Edward II. the Jews were banished the kingdom, and the mines were neglected. Edmund, the eldest son of the king, and Earl of Cornwall, however, made some important alterations in the regulations of the tin works, by a charter, which was confirmed by Edward I., in the latter part of his reign. Indeed, it is from this time that the peculiar laws and privileges relating to the Stannaries are to be dated. Mining infringed in some instances upon property, and caused disputes, besides requiring indulgences, not general; and thus cases arose, not cognizable by the common law. In this way a peculiar code, springing from custom, took its rise; and, though it in some measure existed before, yet it was not till this period that it was confirmed by royal charter, and enforced by subsequent acts of Parliament. It was by this charter that the bounding of land for the purpose of tinners working on it, the duties to the earl of Cornwall, and the coinages of tin, or stamping with the earl's seal, were established. Before the reign of Edward I. tinners worked on the earl's land only, paying him a fifteenth part of what they obtained; they were not permitted to dig in sanctuary ground, churches, mills, houses, gardens, and so on; and if, in working under, they chanced to damage any house or highway, they were obliged to make it good. When it became an object to search throughout any place or person's land, a court also to determine cases belonging to the tin works was necessary; and this, adjudging under the authority of, and according to the code of laws before-mentioned, was first established by Edward, and is called the "Stannary Court."

The ores are found in veins, or, as they are provincially called, *lodes;* the most important of which generally run in an east and west direction. These lodes vary considerably in breadth; the average may be taken at from one foot to four feet: for in some cases they are only a barley-corn in width, while in Nangiles mine the lode is in some places thirty feet wide, and in Relistion mine it is even thirty-six feet wide. The width of a lode is by no means regular; for it will vary from six inches to two feet in the space of a few fathoms.

The deepest mine in this country now at work is Dolcoath, so named from an old woman, Dorothy Koath, who lived on the spot when the working of the mine commenced. The appearance of the shaft of the Dolcoath mine, with the connecting machinery, is well given in the accompanying engraving.



The mines of that neighbourhood alone give employment to more than 2000 men. The east and west lodes are cut by others, called *cross courses*, which run north and south, and not only cause an interruption to the lodes, but alter their position, so that the miners must search, generally to the right hand, to find them again; it is very rare that left-handed heaves occur. These heaves occasion much trouble to the miners; in H… Pever it took a search of forty years to recover … lode.

When adventurers determine to work a mine, t… have agreed with the proprietor of the soil respec… his share, *or dish,* three points are to be consider… 1. The discharge of the water that may be met w… 2. The removal of the *deads,* that is, the barren r… and rubbish. 3. The raising of the ore. The f… object, therefore, is to cut an adit, or undergro… passage, about six feet high and two feet and a l…

wide, from the bottom of some neighbouring valley, up to the vein. This is a considerable expense; but still, in the end, it is the most economical mode of getting rid of the water, which must otherwise be raised by pumping, an operation which must still be resorted to in regard to that part of the mine which is below the upper part of the adit. Some of these adits are of great length; the one into which the steam-engine of Chacewater mine pumps its water is not less than twenty-four miles long: it is the deepest adit in Cornwall, and flows into one of the creeks of Falmouth Haven.

As soon as the vertical opening or shaft is sunk some depth, a whim is erected, to bring up the deads and ore in baskets, called *kibbuls*, one of which goes down empty while another comes up full. The whims are turned by horses, steam, or other power. As the lode never runs down perpendicularly, it is necessary to cut galleries, called levels, generally about two feet wide and six feet high, in a horizontal direction. Other shafts are also sunk, which traverse the several levels; or a special communication is made between only two galleries by a particular shaft called *wins*. When several levels run parallel to each other through the rock, or country, as it is called, they are made to communicate by other levels, called cross cuts.

For keeping the galleries from being inundated, each mine is furnished with a chain of pumps, descending from the adit level to the bottom of the mine, or *sump*, as it is called: all these pumps are worked by a single pump-rod, moved by steam-engines, whose aggregate power is frequently equivalent to the labour of more than 1000 men. The water is raised by these pumps, each of which receives the water brought up by the one immediately below it, until it reaches the adit, through which it flows by a gentle descent to the surface.

The subterranean excavations are effected by breaking down the looser parts with a pick-axe, or by blasting the more solid parts by gunpowder. No less than 30,000*l.* worth of this article is annually consumed in the mines of this country. (See IRON, and the other metals in their alphabetical order.)

MINERAL WATERS. Fluids generally take up a vast variety of ingredients, many of which are of great value in a medicinal point of view. Our own country has many mineral springs in which medicinal properties are found to reside: and, if this vast natural laboratory beneath the earth's surface were better known, there is no doubt but what it would be more generally resorted to. We purpose, in the first instance, giving a list of these springs, and then showing the mode of analysing their contents.

The following is an alphabetical table of the most celebrated medicinal waters in Europe, showing their peculiar medicinal properties.

[illegible]mes of Springs.	*Places in which they are found.*	*Medicinal Virtues.*
[illegible]ourt	Near St. Germains, France	Diuretic and purgative.
[illegible]n	Middlesex	Strongly purgative.
[illegible]aloo	Tyrone, Ireland	Alterative. Useful in scrofulous and cutaneous diseases.
[illegible] la-Chapelle	Juliers, Germany	Diaphoretic, purgative, & diuretic. Used as baths, as well as taken internally. Useful in rheumatisms, & all diseases proceeding from a debility of the system.
Alford, or Awford	Somersetshire	Strongly purgative.
Arbroath	County of Forfar, Scotland	Diuretic. Used in indigestions, nervous disorders, &c.
Askeron	Yorkshire	Diuretic.
Antrim	Ireland	Similar to Borrowdale water, but weaker
Baden	Suabia, Germany	See *Aix-la-Chapelle*, which it resembles in medicinal properties.
Bagnigge wells	Middlesex	Strongly purgative.
Ball, or Baudwell	Lincolnshire	Astringent. Drank to the quantity of two pints, or two and a half.
Balaruc	Languedoc, France	Drank as a purgative, and used for hot-baths.
Ballynahinch	Down, Ireland	Useful in scorbutic disorders, and diseases of indigestion.
Bagniers	Biggore, France	The waters used for baths, like those of Aix-la-Chapelle. Some of the springs are purgative, and others diuretic.
Bareges	Biggore, France	Diuretic and diaphoretic. Useful in nervous and cutaneous disorders.
Barnet, and Northhall	Hertfordshire	Purgative.
Bath	Somersetshire	Highly useful in cases of gout, rheumatism, indigestion, palsy, and biliary obstructions. The temperature varies from 93° to 117° Fah.
Bandola	Italy	Gently laxative, diuretic, and diaphoretic.
Beulah	Surrey	Highly purgative. This has now become a place of fashionable resort, and the botanical lectures delivered by Dr. Dickson in the grounds were well attended during the last season (1833).
Borrowdale	Cumberland	Emetic and Cathartic.
Brentwood	Essex	Purgative.
Bristol	Somersetshire	Used as a bath. Useful in consumptions.
Bromley	Kent	Diuretic and corroborative.
Broughton	Yorkshire	Similar to Harrowgate.
Buxton	Derbyshire	Useful in gout and rheumatism. Used as baths, and drank to the quantity of five or six pints per day.
Caroline baths	Bohemia	Purgative, and used as baths. Of service in disorders of the stomach & bowels, scrofula, &c.
Carlton	Nottinghamshire	Diuretic and corroborative.
Carrickfergus	Antrim, Ireland	Weakly purgative.
Carrickmore	Cavan, Ireland	Purgative and diuretic.
Cashmore	Waterford, Ireland	Purgative, diuretic, and sometimes emetic.
Castle-Leod	Ross-shire, Scotland	Diuretic and diaphoretic. Useful in cutaneous diseases.
Castlemain	Kerry, Ireland	Diuretic.
Cawley	Derbyshire	Gently purgative.
Cawthorp	Lincolnshire	Purgative.
Chadlington	Oxfordshire	Purgative.
Chaude Fontaine	Liege, Germany	Resembles those of Aix-la-Chapelle and Buxton.
Cheltenham	Gloucestershire	Purgative and corroborant. Is useful in cases of indigestion and scorbutic disorders; also in the gravel.
Chippenham	Wiltshire	Diuretic.
Cleves	Germany	Diuretic.
Clifton	Oxfordshire	Gently laxative, and used as a bath for cutaneous disorders.
Cobham	Surrey	Purgative and diuretic.
Colchester	Essex	Strongly purgative.
Comner, or Cumner	Berkshire	Purgative, in the quantity of one, two, or three quarts.
Coolauran	Fermanagh, Ireland	Diuretic.
Corstorphin	Mid-Lothian, Scotland	Diuretic and laxative.

Names of Springs.	*Places in which they are found.*	*Medicinal Virtues.*
Coventry	Warwickshire	Purgative and diuretic.
Crickle-Spa	Lancashire	Purgative, and resembling Harrowgate water.
Croft	Yorkshire	Purgative.
Cross-town	Waterford, Ireland	Diuretic, purgative, and sometimes emetic.
Cunley-house	Lancashire	Purgative and diuretic.
D'Aix en Foix	Thoulouse, France	Used as a bath, and also drank like the Aix-la-Chapelle waters.
Deddington	Oxford	Alterative and purgative.
Derryhinch	Fermanagh, Ireland	Diuretic and diaphoretic.
Derrindaff	Cavan, Ireland	Diuretic.
Derrylester	Cavan, Ireland	
Drig-well	Cumberland	
Dropping-well	Yorkshire	Astringent.
Drumas-nave	Leitrim, Ireland	Powerfully diuretic and anthelmintic, and of use in cutaneous and scrofulous disorders.
Drumgoon	Fermanagh, Ireland	
Dublin salt springs	Ireland	Purgative.
Dulwich	Kent	Purgative and diuretic. Useful in nervous cases and diseases proceeding from debility.
Dunnard	Near Dublin	Diuretic.
Dunse	Berwickshire, Scotland	Strongly chalybeate.
Durham	Durham	Similar to the Harrowgate water.
Egra	Bohemia	
Epsom	Surrey	Purgative.
Fairburn	Ross-shire, Scotland	Alterative, and useful in cutaneous diseases.
Felstead	Essex	
Filah	Yorkshire	Powerfully diuretic and purgative.
Frankfort	Germany	Similar to Harrowgate.
Gainsborough	Lincolnshire	Diuretic and laxative.
Galway	Ireland	
Glenmile	Ireland	
Glastonbury	Somersetshire	
Glendy	Merns county, Scotland	
Granshaw	Down, Ireland	
Haigh	Lancashire	Emetic and cathartic.
Hampstead	Middlesex	Alterative and diuretic.
Hanbridge	Lancashire	Purgative.
Hanlys	Shropshire	Purgative.
Harrowgate	Yorkshire	Alterative and purgative. Useful in scurvy, scrofula, and cutaneous diseases.
Hartfell	Annandale, Scotland	Astringent.
Hartlepool	Durham	Diuretic and laxative.
Holt	Wiltshire	Mildly purgative.
Joseph's-well	Stock Common, near Cobham, Surrey	Alterative, purgative, and diuretic.
Ilmington	Warwickshire	Diuretic and laxative.
Inglewhite	Lancashire	Alterative. Useful in scorbutic and cutaneous diseases.
Kanturk	Cork, Ireland	
Kedleston	Derbyshire	Similar to Harrowgate; but intolerably fetid.
Kilbrew	Meath, Ireland	Emetic and cathartic.
Kilburn	Near London	Purgative.
Killasher	Fermanagh, Ireland	Similar to Swadlingbar water.
Killingshanvally	Fermanagh, Ireland	Diuretic.
Kilroot	Antrim, Ireland	
Kinalton	Nottinghamshire	Purgative.
Kincardine	Merns, Scotland	
Kingscliff	Northamptonshire	
Kirby	Westmoreland	Laxative, and useful in correcting acidities.
Knaresborough	See *Dropping-well*	
Knowsley	Lancashire	
Kuka	Bohema	Operates by insensible perspiration.
Latham	Lancashire	
Llandrindod	Radnor, South Wales	Useful in the scurvy, and cutaneous disorders.
Llangybi	Caernarvonshire, North Wales	Useful in disorders of the eyes, scrofula, &c.
Leamington	Warwickshire	Emetic and cathartic.
Lees	Essex	
Lincomb	Somersetshire	

Names of Springs.	*Places in which they are found.*	*Medicinal Virtues.*
Lisbeak	Fermanagh, Ireland	Similar to Swadlingbar water.
Lis-done-Vurna	Clare, Ireland	Emetic, cathartic, and diuretic.
Mahereberg	Kerry, Ireland	Similar to Borrowdale water.
Mallow	Cork, Ireland	Useful in consumptions.
Malton	Yorkshire	Similar to Scarborough water.
Malvern	Gloucestershire	Diuretic and cathartic.
Markshall	Essex	
Matlock	Derbyshire	
Maudsley	Lancashire	Purgative.
Mechan	Fermanagh, Ireland	Purgative.
Miller's Spa	Lancashire	
Moffat	Annandale, Scotland	Diuretic, and sometimes purgative.
Moss-house	Lancashire	Strongly purgative.
Moreton	Shropshire	
Mont d'Or	France	Diuretic, purgative, and diaphoretic.
Nevel Holt	Leicestershire	Purgative, diuretic, and diaphoretic. — Powerfully antiseptic in putrid diseases, and excellent in diarrhœa, dysenteries, &c.
New Cartmall	Lancashire	Purgative.
Newnham Regis	Warwickshire	
Newtondale	Yorkshire	Astringent.
Newton-Steward	Tyrone, Ireland	
Nezdenice	Germany	Diuretic, diaphoretic, and tonic.
Nobber	Meath, Ireland	Similar to Hartfell.
Normanby	Yorkshire	Similar to Askeron water.
Nottington	Dorsetshire	Useful in cutaneous diseases.
Orston	Nottingham	Purgative.
Oulton	Norfolk	
Owen Breun	Cavan, Ireland	Diuretic.
Passy	Near Paris	
Pettigoe	Donnegal, Ireland	Diuretic.
Pitkeathly	Perthshire, Scotland	Gently purgative.
Pontgibault	Auvergne, France	Diuretic and laxative.
Pougues	Nivernois, France	Diuretic and laxative.
Pyrmont	Westphalia, Germany	Diuretic, diaphoretic, and laxative. Recommended in cases where the constitution is relaxed.
Queen Camel	Somersetshire	Used in scrofulous and cutaneous disorders.
Richmond	Surrey	
Rippon	Yorkshire	Diaphoretic.
Road	Wiltshire	Useful in scrofula, scurvy, and cutaneous disorders.
St. Bernard's well	Near Edinburgh	A very valuable spring, much used in scorbutic diseases. It is diuretic and purgative.
St. Erasmus's well	Staffordshire	Similar to Borrowdale water.
Scarborough	Yorkshire	Diuretic and purgative.
Sedlitz	Bohemia	Strongly purgative.
Seltzer	Germany	Diuretic. Useful in the gravel, rheumatism, scurvy, scrofula, &c.
Sene, or Send	Wiltshire	
Seydschutz	Germany	
Shapmoor	Westmoreland	Diuretic.
Shettlewood	Derbyshire	Purgative.
Shipton	Yorkshire	Similar to Harrowgate.
Somersham	Huntingdonshire	Corroborant & alterative.
Spa	Liege, Germany	Diuretic and purgative.
Stanger	Cumberland	Emetic and cathartic.
Suchaloza	Hungary	Diuretic and tonic.
Sutton Bog	Oxfordshire	Alterative and laxative.
Swadlingbar	Cavan, Ireland	Alterative and diaphoretic.
Sydenham	Kent	Purgative.
Tarleton	Lancashire	Diuretic and purgative.
Tewksbury	Gloucestershire	Strongly purgative.
Thetford	Norfolk	Purgative and diuretic.
Thursk	Yorkshire	Diuretic and purgative.
Tibshelf	Derbyshire	Similar to Spa water.
Tilbury	Essex	Diuretic and diaphoretic.
Tober Bony	Near Dublin, Ireland	Similar to Tilbury.
Tonstein	Cologne, Germany	Similar to Seltzer, but more purgative.
Tralee	Kerry, Ireland	

Names of Springs.	*Places in which they are found.*	*Medicinal Virtues.*
Tunbridge	Kent	An excellent chalybeate, useful in all diseases for which the Spa is recommended.
Upminster	Essex	Purgative and diuretic.
Vahls	Dauphiny, France	Diuretic and laxative.
Wardrew	Northumberland	Similar to Harrowgate water.
Weatherstack	Westmoreland	Purgative.
Whiteacre	Lancashire	Astringent.
Wigglesworth	Yorkshire	Emetic.
Wildungan	Waldeck, Germany	Useful in scorbutic and gouty diseases.
Witham	Essex	Diuretic and alterative.
Wirksworth	Derbyshire	Useful in scrofulous and cutaneous diseases.
Zahorovice	Germany	Much esteemed in scrofulous cases.

The first step in the *analysis* of a *mineral water* is to ascertain the gaseous substances it contains, as these frequently contribute to hold the solid substances dissolved.

Carbonic acid uncombined, or in excess, may be discovered by the pungent acidulous taste of the water, and its sparkling appearance when poured into a glass. Waters impregnated with it become vapid from exposure to the air, or to a moderate heat, from the escape of the gas.

The chemical tests to discover it are infusion of litmus and lime-water, the former receiving from the mineral water an evanescent redness, the latter producing a milkiness or precipitation, which disappears when an excess of the mineral water is added, the carbonic acid rendering soluble the carbonate of lime, to which the turbid appearance is owing. The transparency is equally restored by dropping into the liquid a little muriatic or nitric acid. By the evanescent redness given to litmus, carbonic acid is distinguished from any other free acid that might be present; and, by the transparency being restored by these re-agents, the fallacy that might arise from the precipitation of the lime by any sulphate in the water is guarded against. The quantity may be ascertained by exposing the water to heat in a retort, collecting the gas disengaged in a jar over mercury, and introducing a solution of potash, by which the carbonic gas is absorbed.

Sulphurous acid gas is very seldom to be looked for; when present, it is discovered by its smell, by giving a permanent red colour to a solution of litmus, and by rendering colourless an infusion of roses. Its quantity is estimated by expelling it; exposing the gas to a solution of potash, and obtaining the sulphite of potash; or by adding to it sulphuretted hydrogen gas as long as any diminution of volume is produced, these two gases, by their mutual action, being converted into water and sulphuric acid, and being therefore entirely condensed.

Nitrogen gas is discovered by remaining unabsorbed when the elastic fluid, expelled from a mineral water by heat, has been exposed to a solution of potash.

Sulphuretted hydrogen existing in a water is discovered by its smell, by the deposition of sulphur from it on exposure to the air, or, on the addition of nitrous acid, by blackening silver or mercury immersed in it, and affording a dark-coloured precipitate with acetate of lead. The quantity has been estimated by expelling it from the water by heat, but the whole of it cannot thus be expelled; nor can it easily be collected to be measured with accuracy, as it is absorbed by water, and acts on quicksilver. It may be decomposed by the addition of fuming nitrous acid, or, according to Kirwan's method, a quantity of the water, so as to combine with the oxygen of the atmosphere; nitrous acid is formed, and this, being absorbed by the water, decomposes the sulphuretted hydrogen; the quantity may be inferred from the quantity of sulphur precipitated, and collected on a filter, thirty-four grains of sulphur being held equivalent to 100 cubic inches of sulphuretted hydrogen gas. When sulphuretted hydrogen and carbonic acid gases exist together in mineral water, the elastic fluid obtained from the water by heat is exposed in a tube to nitrous acid, by which the sulphuretted hydrogen is immediately absorbed and decomposed.

After the gaseous substances in mineral waters have been ascertained, the solid contents are to be examined.

The mineral acids, when combined with any base, or in excess, are discovered by the water giving a permanent red colour to vegetable infusions; but in this state they are very rarely present.

The neutral and earthy salts are the chief ingredients of mineral water. We have to ascertain the acids they contain, and the bases with which these are united; and for this purpose it is in general necessary to reduce the volume of the water by evaporation, to render more sensible the operation of the re-agents by which they are detected; only taking care, when the evaporation is executed with this view, not to carry it so far as to give rise to the separation of any of the solid ingredients.

Sulphuric acid, in combination with the alkalies or earths, is detected by muriate of barytes, acetate of lead, and nitrate of mercury, all of these causing an immediate precipitation. The first is at once the most delicate and most accurate, and the others therefore may be regarded as superfluous. Its delicacy is such that it discovers the most minute quantity of sulphuric acid. The only fallacy to which it is liable is that of affording a precipitate from the presence of an alkaline or earthy carbonate; this is obviated by adding, previously to the water, a small quantity of pure nitric or muriatic acid, or by the turbid appearance, after it has been produced, disappearing, if it has arisen from this, on the addition of a few drops of either of these acids.

Muriatic acid is detected by nitrate of silver, the muriate of silver which is formed being, from its insolubility, instantly precipitated, and giving rise to a bluish turbid appearance. The delicacy of this as a re-agent is great, the most minute quantity of muriatic acid in any state of combination being detected. It is liable to fallacy, however, from a precipitate being likewise produced by it from the presence either of any carbonate or any sulphate. The operation of the former is obviated by the previous addition of a few drops of pure nitric acid, which decompose the carbonate and expel the carbonic acid; to avoid the latter it is necessary to decompose any sulphate by the addition of nitrate of barytes.

Carbonic acid, in combination with the alkalies or earths, may be discovered by the effervescence produced by the addition of sulphuric acid when concentration has been produced by evaporation, and by muriate of barytes forming a precipitate soluble with effervescence in nitric or muriatic acid. The alkaline carbonates are distinguished by their power of changing the vegetable colours; the earthy and

metallic carbonates, by being precipitated when the water is partly evaporated.

These are the acids usually met with in mineral waters; they are commonly combined with the fixed alkalies, lime, magnesia, or alumina, or with oxide of iron.

Lime is *immediately* precipitated by oxalic acid. Some of the mineral acids, however, either decompose this acid, or hold dissolved the precipitate it forms with the lime, and hence, if disengaged by the decomposition, they might have this effect. This fallacy is guarded against by using, not the pure acid, but oxalate of potash or ammonia, the alkali neutralizing the acid disengaged from the lime. Oxalic acid produces a precipitate likewise with magnesia, but this takes place very slowly, even when the magnesian salt is in large quantity, while with lime it is immediate. Sulphuric acid is also a test to discover lime, but it is one of much less delicacy.

Ammonia and lime-water are the tests of magnesia; the former precipitating it partially, the latter entirely. In order that the lime may be an accurate test, it is necessary to remove any carbonic acid which may exist in the water, by previously adding nitric acid; and any sulphuric acid, by muriate of barytes. Another source of fallacy more important arises from alumina being precipitated by the re-agents as well as magnesia. The nature of the precipitate may be discovered by dissolving it in nitric or muriatic acid, and again precipitating the solution by carbonate of potash. If this dried precipitate be subjected to the action of diluted sulphuric or muriatic acid it will be immediately dissolved if the earth be magnesia; while, if it be alumina, it will dissolve slowly; or the precipitate may be boiled in a solution of potash; if it be alumina it will be dissolved, while magnesia will remain undissolved. Succinate of ammonia too precipitates alumina, but not magnesia. But the best mode of discovering magnesia is by the formation of its triple phosphate with ammonia. This may be effected by the method of Dr. Wollaston, by adding carbonate of ammonia to a solution containing any magnesian salt; no effect appears, but on adding phosphate of soda precipitation takes place; or the same result may at once be obtained by adding sub-phosphate of ammonia.

The alkalies, when in a state of combination, cannot be discovered by any striking tests, but their presence is inferred when acids are discovered in a mineral water which are not free, and which, at the same time, from the application of tests, do not appear to be combined with earthy or metallic bases.

Soda is the alkali generally present. The peculiar salts which it and potash form with the different acids serve to distinguish them. With oxalic acid, soda forms a salt sparingly soluble; while potash forms, with the same acid, a salt easily dissolved. With tartaric acid, on the contrary, soda forms a soluble salt; while with potash an acidulous tartrate is formed, of comparatively sparing solubility. Muriate of platina affords a test still more delicate, giving a precipitate with the salts of potash, but not with those of soda.

Silicious earth is contained in some waters, not combined, however, with any acid. A portion of alkali, likewise, generally exists in such water; but this is either in the state of a carbonate, or in such small quantity that it can scarcely be considered as the solvent of the silex. This earth may be discovered by evaporating the water, and adding nitric or muriatic acid to the solid residuum; the silex will remain undissolved; and its nature may be still more clearly proved by fusing it with the blow-pipe, with either of the fixed alkalies.

Of the metals existing in mineral waters, iron is the principal; any other, indeed, is of very rare occurrence. It is combined sometimes with sulphuric acid, but more generally with carbonic acid.

Chalybeate waters, as those impregnated with iron are named, deposit an ochrey sediment, on exposure to the air. The iron is discovered by very delicate tests, principally infusion of galls and prussiate of potash, the former striking a purple colour, the other giving rise to a blue precipitate. The latter is liable to fallacy, principally from the iron which exists in its composition, and which is liable to be evolved by an acid, so as to give rise to the blue precipitate. The former is not liable to this or any other important fallacy, and is much more delicate, a deep colour being struck when the iron is present in very small proportion. The colour is liable to be varied by the action of various salts, alkaline and earthy carbonates rendering it violet, neutral alkaline salts deepening the purple tint, and sulphate of lime rendering the precipitate at first whitish and afterwards black. Carbonate of lime has a singular effect. If the iron is in small quantity, and at a high state of oxidation, the colour does not appear; while, if it is in a low state of oxidation, the purple tint is even heightened. By applying this test before and after ebullition of the mineral water, we discover whether the oxide of iron has been dissolved by carbonic acid or sulphuric acid: if the former has been the solvent, being expelled during the boiling, the oxide is precipitated, so that either the liquor, after filtration, when cold, does not suffer the change of colour, or the tint is much less deep. The quantity of oxide may be in some measure determined by its precipitation from exposure to the air and ebullition; or it may be precipitated by succinate of soda, and the precipitate, calcined at a red heat with a little carbonaceous matter, gives the quantity of oxide of iron. Benzoate of soda may be substituted as more economical.

Besides the method of discovering the saline ingredients in mineral waters by re-agents which indicate their principles, they may, by certain methods, be obtained in their entire state, and their quantities determined.

Evaporation is employed with this view, different substances being obtained as the evaporation is carried to a greater or less extent. Thus the carbonates of lime and magnesia are usually first precipitated, afterwards sulphate of lime falls down: if after these precipitations the liquor be drawn off and allowed to cool, the alkaline neutral salts and the sulphate of magnesia will crystallize, while muriate of magnesia and muriate of lime, if present, will remain, forming an uncrystallizable residue.

Alcohol facilitates the analysis by a similar operation. When added to the water brought to a certain state of concentration, it throws down first sulphate of lime, afterwards carbonate of lime and carbonate of magnesia; and if added in larger quantity, or after a renewed evaporation, it either precipitates or causes to crystallize sulphate of magnesia and sulphate of soda, while any muriates remain dissolved. Advantage, too, is taken of its solvent power, the solid sub-

stances being obtained by evaporation to dryness, and their separation being facilitated by the addition of alcohol in successive portions.

It is by these methods of evaporation and precipitation that the ingredients of mineral waters have been determined. By the use of re-agents, their principles are discovered, and even the quantity of these may be estimated. The quantity, for example, of sulphuric acid may be ascertained from the weight of the precipitate formed by adding muriate of barytes, the proportion of sulphuric acid which a given weight of this brought to a certain state of desiccation contains being known: the quantity of muriatic acid may be inferred from the weight of the precipitate formed by adding nitrate of silver; that of carbonic acid from the weight of the precipitate formed by water of barytes or lime; that of lime from the weight of the oxalate of lime precipitated by oxalate of potash; and, in a similar manner, the weights of other substances that can be precipitated by re-agents in new states of combination may be determined. But it is always from the substances actually obtained that the composition is previously inferred, these being supposed to be the ingredients which exist in solution. (See Water, Analysis of.)

Mite; a small coin, formerly current, equal to about one-third of a farthing; it also denotes a small weight used by the moneyers. It is equal to the 20th part of a grain, and divided into 24 doits.

Mitre, in *architecture*, is the workman's term for an angle of forty-five degrees, or half a right one. If the angle be a quarter of a right angle, they call it a *half-mitre*. To describe such angles, they have an instrument called the *mitre-square*; with this they strike the mitre-lines on their quarters or battens; and, for despatch, they have a *mitre-box*, as they call it, which is made of two pieces of wood, each about an inch thick, one nailed upright on the edge of the other; the upper piece has the mitre-lines struck upon it on both sides, and a kerf to direct the saw in cutting the mitre-joints readily, by only applying the piece into this box.

Mnemonics, the art of assisting the memory. One species of mnemonics, and perhaps the earliest, is to attach the idea to be remembered to some impression of the senses, such as those external objects which are most familiar to our eyes. Some persons make use of a picture, arbitrarily drawn, to which they attach the subjects to be remembered, in a certain order; others make use of numbers. There are certain natural aids to the memory, which we all employ: for instance, if we put a piece of paper in a conspicuous part of a room, or make a knot in a handkerchief, in order to be reminded of certain things at particular times. An orator who intends to deliver a long speech without notes may derive assistance from previously entering the room where he is to speak, and attaching in his mind to certain prominent objects in the room the chief heads of his speech. To remember dates, several methods have been advised. The one proposed in Gray's *Memoria Technica* is to make certain changes in the names of persons, places, &c., in such a way that the words shall signify also certain numbers, according to a plan previously adopted. A table must be drawn up, similar to the following:—

a	*e*	*i*	*o*	*u*	*au*	*oi*	*ei*	*ou*	*y*
1	2	3	4	5	6	7	8	9	0
b	*d*	*t*	*f*	*l*	*s*	*p*	*k*	*n*	*x*

If we now wish to impress in our memory that Julius Cæsar arrived at the supreme power 46 B. C., we may change the *Julius* into *Julios*, which will be easily remembered whenever we think of *Julius*, and *os* signifies, according to the above plan, 46. If we wish to remember that Alexander the Great founded his empire 331 B. C., we change *Alexander* into *Alexita*, *ita* signifying 331 according to the above. In the same way *Cyrus*, changed into *Cyruts*, gives the year of the foundation of his great empire. This method may much facilitate the retaining of facts to a certain extent; but it would seem as if the changes themselves might become too numerous to be easily remembered.

Systems of mnemonics of a more *general* character have been proposed; few, however, or none, have remained in vogue for any length of time. Generally speaking, mnemonics ought to be individual: each person should find out that method of assisting his memory which is most convenient to himself; and this will vary, of course, with his habitual associations. The only true basis of a philosophic memory, however, is just classification.

Considerable aid to the memory may be derived from the use of rhymes, or a rhythmical arrangement of words. Before the invention of writing, rhythm was employed to preserve the memory of historical facts. The ancients were well acquainted with mnemonics; according to some, the science came from the East to the Greeks; others consider the poet Simonides as the inventor of them; but such inventions cannot be properly assigned to any particular individual. In the time of Cicero it was known among the Romans. After Quintilian's time, mnemonics again declined. In considering the use of mnemonics by the ancient orators, we should remember that they delivered long orations indeed, but had nothing like our debates, in which a member of a deliberative body sometimes rises, and speaks for hours in succession, recapitulating all which has been said before him on the question, and therefore, to a considerable degree, without premeditation. Most of the systems of mnemonics devised for the ancients would be useless for a parliamentary orator of the present day. In the place of the ancient mnemonics, the schoolmen used the tabulary method. Conrad de Celtes, in the fifteenth century, and Schenkel, in the sixteenth, re-established the ancient system. In modern times, several scholars have given much attention to this subject. The degree to which the power of memory has been sometimes carried is almost incredible. Thus Seneca states that, by the mere effort of his natural memory, he was able to repeat 2000 words upon once hearing them, each in its order, though they had no dependence or connexion on each other. He also mentions Cyneas, ambassador to the Romans from king Pyrrhus, who in one day so well learnt the names of the people whom he saw that the next day he saluted all the senators, and all the populace assembled, each by his proper name. Pliny says that Cyrus knew every soldier in his army by name, and L. Scipio all the people of Rome. Charmipas, or rather Carneades, it is said, would repeat the contents of any volume found in the libraries, as readily as if he were reading. Dr. Wallis tells us that, without the assistance of pen and ink, or any thing equivalent, he was able, in the dark, by the mere force of memory, to perform arithmetical operations, as multiplication, division, extraction of roots

&c., to forty places. It is said of Magliabecchi that a gentleman having lent him a manuscript, which he was going to print, came to him soon after it was returned, and, pretending that he had lost it, desired him to repeat as much of it as he could; on which Magliabecchi wrote down the whole, without missing a word or varying the spelling.

Moat, or Ditch, in *fortification;* a deep trench dug round a rampart of a fortified place. The brink of the moat next the rampart is called the *scarp;* and the opposite one the *counter-scarp.* A dry moat round a large place, with a strong garrison, is preferable to one full of water, because the passage may be disputed inch by inch, and the besiegers, when lodged in it, are continually exposed to the bombs, grenades, and other fire-works, which are thrown incessantly from the rampart into their works. In the middle of dry moats, there is sometimes another small one called a *lunette,* which is generally dug till the water fills it. The deepest and broadest moats are accounted the best; but a deep one is preferable to a broad one: the ordinary breadth is about twenty fathoms, and the depth about sixteen. To drain a moat that is full of water, a trench is dug deeper than the level of the water, to let it run off, and then hurdles are thrown upon the mud and slime, covered with earth or bundles of rushes, to make a sure and firm passage.

Mobility; a contingent property of bodies, but most essential to their constitution. Every body at rest can be put in motion, and, if no impediment intervene, this change may be effected by the slightest external impression. Thus the largest cannon ball, suspended freely by a rod or chain from a lofty ceiling, is visibly agitated by the horizontal stroke of a swan shot which has gained some velocity in its descent through the arc of a pendulum. In like manner, a ship of any burden is, in calm weather and smooth water, gradually pulled along even by the exertions of a boy. A certain measure of force, indeed, is often required to commence or to maintain the motion; but this consideration is wholly extrinsic, and depends on the obstacles at first to be overcome, and on the resistance which is afterwards encountered. If the adhesion and intervention of other bodies were absolutely precluded, motion would be generated by the smallest pressure, and would continue with undiminished energy.

Mode, in *music;* a particular system or constitution of sounds, by which the octave is divided into certain intervals, according to the genus. The theories respecting the ancient modes are rendered somewhat obscure, by the difference among their authors as to the definitions, divisions, and names of their modes. While the ancient music was confined within the narrow bounds of the tetrachord, the heptachord, and octachord, there were only three modes admitted, whose fundamentals were one tone distant from each other. The gravest of these was called the Dorian; the Phrygian was in the middle, and the acutest was the Lydian. In dividing each of these tones into two intervals, place was given to two other modes, the Ionian and the Æolian, the first of which was inserted between the Dorian and Phrygian, and the second between the Phrygian and Lydian. The system being at length extended both upward and downward, new modes were established, taking their denomination from the first five, by joining the preposition *hyper* (over or above) for those added at the acute extremity, and the preposition *hypo* (under) for those below. Thus the Lydian mode was followed by the Hyper-Dorian, the Hyper-Ionian, the Hyper-Phrygian, the Hyper-Æolian, and the Hyper-Lydian, in ascending; and the Dorian mode was succeeded by the Hypo-Lydian, Hypo-Æolian, Hypo-Phrygian, Hypo-Ionian, and the Hypo-Dorian in descending. The moderns, however, reckon only two modes, the major and the minor. The major mode is that division of the octave by which the intervals between the third and fourth, and seventh and eighth, become half tones, and all the other intervals whole tones. The minor mode is that division by which the intervals between the second and third, and fifth and sixth, become half tones, and all the others whole tones. Another distinction also exists between the major and minor modes: the major mode is the same both ascending and descending; but the minor mode in ascending sharpens the sixth and seventh, thereby removing the half tone from between the fifth and sixth to the seventh and eighth.

Model; an original of any kind proposed for copy or imitation. It is used, in building, for an artificial pattern formed of stone or wood. In painting, this is the name given to a man or woman who is procured to exhibit him or herself, in a state of nudity, for the advantage of the students. These models are provided in all academies and schools for painting, and the students who have acquired a tolerable use of the pencil are introduced to this kind of study. By this means, the details and proportions of the human shape, the play of the muscles, the varieties of expression, &c., are displayed and inculcated far better than by any course of lectures or any study of former works. It is desirable that the living models used in an academy, or even in a private painting room, should be changed as frequently as possible, or the student is in danger of falling into mannerism. Millin speaks of a model, of the name of Deschamps, who did duty in this way upwards of forty years in the academy at Paris, and comments on the facility with which this person's form and features might be recognized, in every variety of subject or of expression in the paintings of the students of that period.

In sculpture a model implies a figure made of wax or terra cotta, or any other plastic substance, which the artist moulds to guide him in fashioning his work, as the painter first makes a sketch, or the architect a design. When a model of any existing object is to be taken, the original is first to be greased, in order to prevent the plaster from adhering to it, and then to be placed on a smooth table, previously greased, or covered with a cloth, to guard against the same accident; then surround the original with a frame or ridge of glazier's putty, at such a distance as will admit of the plaster resting upon the table, on every side of the subject, for about an inch, or as much as may be thought sufficient to give the proper degree of strength to the mould. An adequate quantity of plaster is then to be poured as uniformly as possible over the whole, until it is every where covered to such a thickness as to give a proper substance to the mould, which may vary in proportion to the size. The whole must then be allowed to continue in this way till the plaster shall have attained its firmness; when, the frame being removed, the mould may be inverted, and the subject taken from it.

Besides the models which are taken from inanimate bodies, it has been frequently attempted to take the exact resemblance of people while living, by using their face as an original for a model from which to take a mould; it may in this case be proper to mix the plaster with warm instead of cold water; and, to prevent any danger from the stoppage of respiration, the following method is to be practised:—Having laid the person horizontally on his back, the head must first be raised by means of a pillow to the exact position in which it is naturally carried when the body is erect; then the parts to be represented must be very thinly brushed over with oil of almonds: the face is then to be first covered with fine fluid plaster, beginning at the upper part of the forehead, and spreading it over the eyes, which are to be kept close, that the plaster may not come in contact with the globe, yet not closed so strongly as to cause any unnatural wrinkles. Then cover the nose and ears, first plugging up the *meatus auditorius* with cotton, and the nostrils with a small quantity of tow rolled up, of a proper size to exclude the plaster. During the time that the nose is thus stopped, the person is to breathe through the mouth: in this state the fluid plaster is to be brought down low enough to cover the upper lip, observing to leave the rolls of tow projecting out of the plaster. When the operation is thus far carried on, the plaster must be suffered to harden; after which the tow may be withdrawn, and the nostrils left free and open for breathing. The mouth is then to be closed in its natural position, and the plaster brought down to the extremity of the face. When the mask is dry, it forms a mould for a perfect cast.

MODILLION; an ornament resembling a bracket, in the Ionic, Corinthian, and Composite cornices. In Grecian architecture, however, the Ionic order is without modillions in the cornice, as are also the Roman examples of the same order, with the exception of the temple of Concord, at Rome, which has both modillions and dentils.

MODULATION, in *music*, is, in its most extensive meaning, the diversified and proper change of tones in conducting the melody, or the progression of tones in general, and the sequences of concords. In its narrower sense, *modulation* signifies that succession of tones by which a musical passage proceeds from one key into another. In quite short pieces, also in those compositions in which the theme remains for some time in the principal tone before it passes to another, good modulation consists only in continuing for some time melody and harmony in the assumed tone, with proper changes and variety, and at last concluding in that tone. For this it is requisite that, at the very beginning, the concord should become distinctly perceptible by the sound of its essential tones, the octave, fifth, and third; and further that the melody, as well as harmony, should be carried through the tones of the assumed scale, and that no tones foreign to it should be heard either in the melody or in the harmony. A variety of concords is however necessary, that the ear may enjoy the necessary change. The rule to let only those tones be heard which belong to the assumed scale is to be understood thus,—that a tone foreign to the scale ought to be used merely in passing, and to be left again immediately; thus, for instance, in the scale *C* sharp, one would certainly go through *G* sharp into *A* flat, and through *F* sharp to the dominant, and from this back again to the principal tone, without violating, by these two tones foreign to the fundamental tone, *C* sharp, the effect of the scale, or destroying it. It is only necessary to avoid tones totally foreign to the scale of *C* sharp; such, for instance, as *D* sharp.

The second kind of modulation, or that which is so called in a more restricted sense, requires more knowledge of harmony, and is subject to greater difficulty. It consists in giving to longer pieces the necessary variety, by more frequent change of tones, and requires a knowledge of the relation among the various keys, and of the tones connecting them. As it is indispensable in longer pieces to carry melody and harmony through several keys, and to return at last to the fundamental, it is necessary, in respect to such modulation, duly to consider the character of the composition, and, in general, whether the modulation has merely in view a pleasing variety or whether it is intended to serve as the support of a grand and bold expression. Considerations of this kind give to the composer the rules for particular cases, and show where he may depart widely from the principal tone and where he should remain near it, where he may thus depart suddenly, and perhaps with some harshness, and where his departures ought to be slow and gradual, because such departures are the most important means of musical expression.

In pieces of a mild and quiet character, it is not permitted to modulate so often as in those which have to express violent and great passions. Where every thing relating to expression is considered, modulation also must be so determined by the expression that each single idea in the melody shall appear in the tone which is most proper for it. Tender and plaintive melodies ought to dwell only on the flat tones; while the lighter sharp tones, which must be touched in the modulation, on account of the connexion, ought to be left immediately afterwards. It is one of the most difficult parts of the art to remain steadily without fault in a modulation. It is therefore to be regretted that those who write on the theory of the art dwell so little on this important subject, and believe that they have done enough if they have shown how the composer may gracefully leave the principal tone, pass through the circle of the ascending and descending scale, and return at last to the first tone.

Piccini had the best views of modulation. "Modulating," he says, "is to pursue a certain path. The ear will follow you; nay, it wishes to be led by you, yet upon condition that, after you have led it to a certain point, it shall find something to reward it for its journey, and to occupy it for some time. If you do not consider its claims, it suffers you to go on, at last, without regard, and every endeavour to attract it again is but lost labour." To conduct a melody according to a given modulation, never to deviate from it except for good reason, and in the right time to return to it in the proper way and without harshness, to make use of changes in the modulation only as means of expression, and perhaps for the necessary variety,—such are the real difficulties of the art; while to leave immediately a key which has hardly been perceived, to ramble about without reason or object, to leap about because the composer does not know how to sustain himself—in one word, to modulate in order to mo-

dulate, is to miss the true aim of the art, and to affect a richness of invention in order to hide the want of it.

MODULE; an architectural measure; the lower diameter of a column being divided into two parts, one is a module, and each module is divided into thirty minutes; thus neither is a determinate, but a proportionate measure. The term is also sometimes used with reference to the different sizes of medals.

MOLE, in *architecture;* a massive work formed of large stones laid in the sea by means of coffer-dams, extended either in a right line or an arc of a circle, before a port, which it serves to close, to defend the vessels in it from the impetuosity of the waves, and to prevent the passage of ships without leave. Thus we say, The mole of the harbour of Messina, &c.

MOLLE, in *music* (soft, or sweet); a relative term, signifying a *flat sound*, that is, a sound which is half a tone lower than the sound with which it is compared,—B flat, or B *molle*, is a semi-tone beneath B natural. This term, as its sense intimates, is applied to the flat sounds on account of their supposed softness or sweetness, in comparison with the effect of the natural and sharp tones.

MOLLITES OSSIUM; a morbid softness of the bones, which become preternaturally flexible, in consequence either of the inordinate absorption of the phosphate of lime, from which their natural solidity is derived, or else of this matter not being duly secreted and deposited in their fabric.

MOLTO, in *music;* a word used in conjunction with some other, by way of augmentation, as *molto allegro*, very quick; *molto adagio*, very slow.

MOLYBDENUM; a metal which has not yet been reduced in masses of any considerable magnitude, but is generally obtained in small, separate globules, of a blackish, brilliant colour. It is extremely infusible. By heat, it is converted into a white oxide, which rises in brilliant, needle-formed flowers. Nitric acid readily oxidizes and acidifies the metal; nitre detonates with it, and the remaining alkali combines with its oxide. Molybdenum unites with several of the metals, and forms with them brittle compounds. The specific gravity of the pure metal is 8.611: it has three degrees of oxidation, forming two oxides and one acid. The *molybdic acid* is composed of forty-eight parts of molybdenum and twenty-four of oxygen; it has a sharp, metallic taste, reddens litmus paper, and forms salts with alkaline bases; specific gravity, 3.4. It is very sparingly soluble in water; but the molybdates of potash, soda, and ammonia, dissolve in that fluid, and the molybdic acid is precipitated from the solutions by any of the strong acids. The *protoxide* of molybdenum is black, and consists of one equivalent of oxygen and one equivalent of molybdenum. The *deutoxide* is brown, and contains twice as much oxygen as the protoxide. Berzelius has formed three chlorides of this metal, the composition of which is analogous to the compounds of this metal with oxygen.

The native *sulphuret* of molybdenum occurs in most primitive countries, disseminated in granite or gneiss rocks, in thin plates of a foliated structure, soft, flexible, slightly soiling the fingers, and greasy to the feeling; colour pure lead-gray; lustre metallic; specific gravity 4.591. It does not melt before the blow-pipe, but emits sulphureous fumes. It is nowhere found in large quantities, although known to exist in numerous places. Its principal European localities are Altenberg, in Saxony, and Schlaggenwald and Zinnwald, in Bohemia. In the United States of America, the largest and best pieces have been found in the gneiss quarries of Haddam, Connecticut, where plates half an inch thick, and four inches over, have been met with. At this place it often exhibits the low six-sided prism. It also occurs at Brunswick, in Maine, in the same rock, and at Chesterfield, Massachusetts, in granite.

MOMENTUM, in *mechanics*, is the same with *impetus*, or quantity of motion, and is generally estimated by the product of the velocity and mass of the body. This is a subject, however, which has led to various controversies between philosophers, some estimating it by the mass into the velocity, as stated above, while others maintain that it varies as the mass into the square of the velocity; but this difference seems to have arisen rather from a misconception of the term than from any other cause, those who maintain the former doctrine understanding *momentum* to signify the momentary impact, and those who hold the latter considering it as the sum of all the impulses, till the motion of the body is destroyed.

MONEY; the common medium of exchange among civilized nations. Money must consist of a material, 1. which has a value of its own; 2. which every man is willing to accept in exchange for his property; 3. whose value is readily ascertained. If this material is moulded into a particular form, and stamped with a mark denoting its value, so that it is appropriated expressly to the exchanging of articles having value, it is called *money*, in distinction from other articles which have value, but which are not used as a medium of exchange. The materials of which money is made, as well as the coin, are merchandise, like other articles that are bought and sold. Different nations have chosen for money different materials, all having more or fewer of the above-mentioned peculiarities. All nations advanced in trade and the arts give preference to metals, especially the precious metals; for, 1. They derive value from the smallness of their quantities, compared with the demand for them in the ornamental and useful arts. 2. They are very little subject to corrosion and destruction by use. 3. They are susceptible of minute division, and may be used in small quantities or masses. 4. They are easily transported, as their transportation to any distance will cost but a small part of their value. 5. The quantity is increased by labour. The advantage of using the precious metals for a universal currency is still greater when persons are appointed under the authority of the law to decide what pieces shall be circulated as money, to stamp them so as to fix their weight and fineness, and to furnish them with the superscription of the authority by which they are authorised. Such pieces are called *coins*, and form the ordinary medium of exchange.

Instead of money, the merchant often receives a promissory note or bill: this substitute is sometimes improperly termed *money*. It is manifest that promissory notes or bills of exchange are of the same value with the real money only while they can be readily exchanged for coin, and that they must lose their value in proportion as the credit of those who issue them sinks. This is true of all paper money, all metallic money whose current value is higher than its real value, and all notes or bonds taken instead of money. That any sort of money may be received

for its real value, or that which it represents, and trade be carried on by means of it, it is necessary that its value should be acknowledged wherever it is used. A distinction, however, is made between money which is received in only one trading-place or small circle, issued in time of peculiar necessity, denominated *tokens*, &c., also coins current in only one country, and money which is every where acknowledged and received, such as bars of gold and silver, of a certain weight and fineness. The exchangeable value of gold and silver, like that of all other commodities, depends, in the first place, on their abundance or scarcity, or, in other words, the quantity supplied in comparison with the quantity wanted, or for which there is a demand; and, in the second place, upon the labour necessary in extracting the ore from the mines, and refining it.

The comparative value of gold and silver is necessarily very nearly the same all over the world, since each metal costs but a trifle for transportation, and both are articles of value every where. The quantities of gold in its various forms of coin and bullion of all descriptions, including bars, plate, &c., have been estimated at 10,000,000lbs. troy weight. A scarcity of money can occur only when, 1. the material of which it is manufactured is deficient; or, 2. when those who are in want of it have nothing to give in exchange to its possessors. In the latter case, there is no real deficiency of money, for there are individuals who, by the terms of the supposition, possess the money: there is only a deficient demand for goods on hand, and those only are in want of money who are unable to dispose of these goods. All mechanics, artisans, and manufacturers, want money enough to purchase the raw materials which they consume, and to pay the wages of their labourers. Merchants need money to pay manufacturers and producers for their goods, and to transport them where they are wanted; and the last consumer needs it to give in exchange for what he eats, drinks, wears, &c., to the dealer of whom he procures the requisite articles. Now, if any one of these classes has not the money required for any of those purposes, there is a scarcity of money for that class of individuals. In these and similar cases, the scarcity of money does not suppose a real scarcity of gold and silver, or a deficiency of coined metals. The scarcity arises from the want of industry, or means, in any class of citizens, to procure the money in circulation, or from their industry being directed to the production of such articles as there is no present demand for among the actual possessors of money; as when, for instance, in grain-growing countries, there is a deficiency of purchasers of the grain produced, there not being consumers enough of the grain, who can obtain or produce desirable articles in exchange for it. In such a case, the producers of grain can obtain money only by exportation of the article to foreign ports. And if it happen that the foreign lands to which it is exported are already provided with grain from some other quarter, it will remain unsold—not because there is no money, but because there is no motive to induce its possessors to part with it for grain.

In places where manufactures of any kind prosper, a certain quantity of money is required to provide the materials. This sum is easily ascertained, according to a certain average, and there is no scarcity of money for these purposes as long as this sum is on hand. But when the manufacture is increased, by the operation of particular circumstances, and the place produces more goods than common upon this account, a scarcity of money may easily occur among those devoted to this branch of business. If now these persons possess goods or credit, they make use of both to obtain the money required from other parts, which will depend, again, upon their being able to pay the expenses of transporting their goods, or to give to the holders of money a higher interest than they can elsewhere obtain. Money, in such cases, becomes of more value in these places than in those where it is not so much in demand; and it follows, from this, that money will leave the places where it is abundant to seek those where, from the want of it, more will be paid for its use; and, in this manner, a scarcity of money will work its own cure.

Money is profitable to any country only by means of its circulation; for circulation makes money the continually repeated cause of the production of new portions of property: and, on this account, a very small sum of money which is in constant circulation is of far more benefit to a country than the possession of the largest sums which remain locked up, and do not change owners. A great quantity of money, therefore, is of no service to a country, unless there are desirable things in that country, for the purchase of which it is to be paid, and thus transferred from one to another. When, therefore, more money flows into any country than will pay for what the country actually produces, money becomes of less value, and the money price of merchandise greater. In this case, it is better to procure the goods from countries where their money price is less. The money will thus be exported again, and procure a return of cheap goods in its place. But, by this process, the industrious part of the population is injured, and those only receive profit who make these exchanges of money for foreign goods. The labouring classes therefore experience a scarcity of money, because the articles which they produce do not command a ready sale. In this manner, all the gold and silver obtained by Spain and Portugal from South America passed into foreign countries in exchange for foreign necessaries. The only true means, then, to remove and to prevent permanently a scarcity of money is to improve the state of domestic and internal industry; and their opinion is wholly destitute of foundation who believe that a mere plenty of money is sufficient to develope a healthy state of domestic industry; for the money does not produce the goods, but follows their production. And money will not stay in a country that does not contain goods upon which it may be expended, but it seeks those countries which produce the objects of desire.

The money now used in this country is formed principally of the precious metals, with which our commercial transactions abundantly supply us; but the gold and silver money at present in circulation is principally of modern coinage, a fact sufficiently proved by the following tables:—

Gold Money.

Year.	Double Sovereigns.	Sovereigns.	Half Sovereigns.
1817	—	3,235,239	1,040,098
1818	—	2,347,230	515,143
1819	—	3,574	—
1820	—	931,994	17,521
1821	—	9,405,114	115,644

Year.	Double Sovereigns.	Sovereigns.	Half Sovereigns.
1822	—	5,356,787	—
1823	30,838	616,770	112,140
1824	1,402	3,767,904	295,769
1825	—	4,200,343	380,575
1826	—	5,724,046	172,415
1827	—	2,266,629	246,007
	32,240	37,855,633	2,895,314

Silver Money.

Year.	Crowns.	Half Crowns.	Shillings.	Sixpences.
1816	—	114,048	1,306,998	384,120
1817	—	1,011,582	1,151,568	273,042
1818	38,808	363,132	67,122	107,118
1819	170,874	598,752	379,764	117,810
1820	112,068	299,574	398,772	37,224
1821	109,494	179,388	123,156	21,582
1822	31,232	—	—	—
1823	—	250,470	34,650	—
1824	—	58,212	207,900	15,840
1825	—	282,348	122,958	12,078
1826	—	273,636	317,592	17,226
1827	—		28,710	4,158
1828	—	1,386	9,504	396
	462,476	3,432,528	4,148,694	990,594

The following document, copied from a paper laid before the House of Commons, gives the quantity of pounds weight of standard gold received into His Majesty's mint from the 6th August, 1831, to the 9th February, 1832, and of the value of gold monies coined, specifying the proportion of each denomination of coin, and stating the amount retained for assaying, loss, and coinage, and how the same has been applied:—

Quantity of gold received in the Mint. Standard weight.	Value of monies coined.	Charges incurred for coinage.	How the charge for coinage has been applied.			
			To the moneyers, by agreement, bearing all waste and expenses in the coinage.	To the melter, by agreement, bearing all waste and expenses.	For the master's regulated fees, applied under act of Parliament.	For contingent expenses in the different offices of the Mint.
lbs. oz. dwt. gr.	*£. s. d.*	*£. s. d.*	*£. s. d.*	*£. s. d.*	*£. s. d.*	*£. s. d.*
12,365 11 14 15	438,046 10 0	3,134 15 3	1,640 12 6	390 12 6	859 7 6	244 2 9

The following is an accurate account of the bank notes or paper money in circulation for four successive years:—In 1829, 20,953,000; 1830, 19,631,000; 1831, 20,575,000; and in 1832, 18,542,000.

The value of the metallic currency, as a medium of circulation, differs considerably in different countries, even in coins of the same name. The following table furnishes a comparative view of their value with reference to our own money: it may, however, be proper to add that commercial changes will make some difference in this amount at different periods.

AUSTRIA AND BOHEMIA.

Gold.

Name of Coin.	dwt.	grs.	English Value. £.	s.	d.
Emperor's Ducat	2	5¾	0	9	5
Hungarian Ducat	2	5¾	0	9	5¼
Half-Sovereign	3	7½	0	14	9
Quarter-Sovereign	1	15¾	0	7	4½
Silver.					
Crown, since 1753	18	1	0	4	1½
Half Rix-dollar, or Florin	9	0½	0	2	0¾
20 Kreutzers	4	6½	0	0	8¼
10 Ditto	2	3¼	0	0	4

BADEN.

Gold.

Name of Coin.	dwt.	grs.	£.	s.	d.
Piece of 2 Florins	4	9	0	16	8¼
1 Florin	2	4½	0	8	4⅛
Silver.					
Piece of 2 Florins	16	2	0	3	3¾
1 Florin	8	1	0	1	7¾

BAVARIA.

Gold.

Name of Coin.	dwt.	grs.	£.	s.	d.
Carolin	6	5¼	1	0	4¼
Maximilian	4	4	0	13	7½
Silver.					
Crown	18	2	0	4	6
Rix-dollar of 1800	17	12	0	4	0½
Teston, or Kôpfstuck	4	6½	0	0	8¼

DENMARK.

Gold.

Name of Coin.	dwt.	grs.	£.	s.	d.
Ducat current since 1767	2	0	0	7	6
Ducat specie, 1791 to 1802	2	5¾	0	9	4¾
Silver.					
Rix-dollar, or Piece of 6 Danish Marks of 1750	17	6	0	4	0
Danish Mark of 16 Schillings of 1776	4	0	0	0	7½

FRANCE.

New Coin.

Gold.

Name of coin.	dwt.	grs.	English Value. £.	s.	d.
20 Franc piece	4	3½	0	15	10¼
40	8	7	1	11	8½
Silver (argent blanc).					
5 Franc piece	16	1	0	4	0
2	6	11	0	1	7
1	3	5½	0	0	9½
½, or 50 centimes	1	15	0	0	4¾
¼, or 25 centimes	0	18½	0	0	2¼
Billon (monnaie grise).					
Piece of 10 centimes			0	0	0¾ .80
Copper, old and new.					
Décime, or 2 sous			0	0	0¾ .80
Sou, or 5 centimes					
Sou, or 1 centime					

HAMBURGH.

Gold.

Name of Coin.	dwt.	grs.	English Value. £.	s.	d.
Ducat ad Legem Imperii	2	5¾	0	9	4¾
New Town Ducat	2	5¾	0	9	4

Name of Coin	dwt.	grs.	English Value £.	s.	d.
Silver.					
16 Schilling Piece, Convention	5	20	0	1	2½
Rix-dollar Specie	18	18	0	4	7
HOLLAND AND BELGIUM.					
Gold.					
Ducat	2	5¾	0	9	5⅜
Ryder	6	10½	1	5	1¼
20 Florins, 1808	9	7¾	1	14	2¾
10 Florins	4	15⅞	0	17	1⅝
10 Williams, 1818	4	7½	0	16	5½
Silver.					
Florin	6	22	0	1	8½
Escalin	3	4⅝	0	0	6
Ducaton, or ryder	20	22	0	5	5
Ducat, or rix-dollar	18	6	0	4	4
LOMBARDO-VENETIAN.					
Gold.					
Sovereign, 1823	8	18	1	7	1
Half Ditto	4	9	0	13	6½
Silver.					
Crown	17	7¾	0	4	1½
Half-Crown, or Florin	8	15⅞	0	2	0¾
Austrian Livre	2	18⅞	0	0	8¼
MOGUL (EAST INDIES.)					
Gold.					
Mohur of Bengal	7	23	1	13	8
Ditto of Bombay	7	10½	1	10	1
Gold Rupee Bombay	7	11	1	9	2
Ditto Madras	7	12	1	9	3
Star Pagoda, Madras	2	4½	0	7	6
Silver.					
Rupee, Sicca	7	12	0	2	0½
Ditto Arcott	7	9	0	1	11¾
Ditto Bombay	7	11	0	1	11
Ditto Broach	7	10	0	1	9
NAPLES.					
Gold.					
New Ounce of 3 Ducats	2	10¼	0	10	5¾
Silver.					
12 Carlini, 1804	17	15	0	4	1¼
2 Carlini, 1804	2	22	0	0	8
1 Ditto, 1804	1	11	0	0	4
Ducat of 10 Carlini, 1818	14	18	0	3	4¼
PAPAL STATES.					
Gold.					
Pistola of Pius VI. and VII.	3	12⅓	0	13	11¼
Half Ditto	1	18⅙	0	6	11⅛
Zecchino, 1769	2	4½	0	9	4⅝
Half Ditto	1	2¼	0	4	8¼
Silver.					
Crown of 10 Paoli	17	1	0	4	3¼
Testone of 3 Paoli	5	2	0	1	3½
——— 20 Paoli	3	10	0	0	10½
Paolo	1	17	0	0	5¼
PARMA.					
Gold.					
Zecchino	2	5¾	0	9	5⅜
40 Lire of Maria Louisa since 1815	8	7¾	1	11	9
20 Ditto	4	3⅞	0	15	10½
Silver.					
Ducat of 1784	16	11	0	4	1¼
Piece of 3 Lire	2	8¾	0	0	6½
5 Lire of Maria Louisa	16	0	0	3	11½
PERSIA.					
Gold.					
Rupee			1	9	1¾
Half Rupee			0	14	6¾
Silver.					
Double Rupee of 5 Abassis			0	3	10½
Rupee			0	1	11½
Abassi			0	0	9
Mamoudi			0	0	4½
Larin			0	0	9½
Gold.					
Lisbonine, or Moidore of 4800 reis	6	22	1	6	11¼
Half Ditto of 2400 reis	3	11	0	13	5½
Quarter ditto of 1200 reis	1	17½	0	6	8¾
Portuguese, or Moiadobra of 6400 reis	9	5⅓	1	15	11
Half Portuguese of 3200 reis	4	14⅔	0	17	10½
Piece of 16 Testons, or 1600 reis	2	7⅓	0	8	11¼
Do. of 12 Tes. or 1200 reis	1	17⅚	0	6	4¼
Do. of 8 Tes. or 800 reis	1	3⅔	0	4	5¾
Cruzada of 480 reis	0	16¼	0	2	7¼
Silver.					
New Cruzada of 480 reis	9	1	0	4	11
PRUSSIA.					
Gold.					
Ducat	2	5¾	0	9	4
Frederick	4	7	0	16	6
Half Ditto	2	3½	0	8	3
Silver.					
Rix-dollar, or thaler of 30 Silbergroschen of 1823	14	6½	0	2	11¼
Piece of 5 Silbergroschen	2	9	0	0	5¾
Silbergros	......		0	0	0¾
RAGUSA.					
Silver.					
Ragusan, or Talaro	18	22	0	3	0
Half Ditto	9	11	0	1	6
Ducat	8	19	0	1	1
12 Grossettes	2	9½	0	0	4
6 Ditto	1	4¾	0	0	2
RUSSIA.					
Gold.					
Ducat	2	5¾	0	9	4½
Imperial of 10 Rubles	7	17¼	1	12	9
Half Ditto	3	20½	0	16	4½
Silver.					
Ruble from 1763 to 1807	15	10	0	3	2
Carlin	10	7¾	1	19	1½
Half Ditto	5	2⅜	0	19	6¾
Pistola	5	10⅓	1	2	6¾
Half Ditto	2	17⅙	0	11	3¼
Silver.					
Crown	15	2½	0	3	8¾
Half-crown	7	13¼	0	1	10¼
Quarter Ditto	4	18⅝	0	11	0
New Crown of 1816	16	0	0	3	11¼
SAVOY AND PIEDMONT.					
Gold.					
Zecchino	2	5¾	0	9	5¾
Double new Pistola of 24 livres	6	4⅓	1	3	9½
Half Ditto	3	2¼	0	11	10¾
New Pistola of 20 livres, 1816	4	3⅔	0	15	10
Carlino, since 1755	30	22⅔	5	19	0
Half Ditto	15	11⅓	2	19	6
Zecchino of Genoa	2	5¾	0	9	6¼
Silver.					
Crown of 6 Livres since 1775	22	14	0	5	7¼

Name of Coin.	dwt.	gr.	English Value. £	s.	d.
Half-crown	11	7	0	2	9½
Quarter Ditto, or 30 Sous	5	15½	0	1	4¾
One-eighth Ditto, or 15 Sous	2	19¾	0	0	8½
New Crown of 5 Livres, 1816	16	1½	0	3	11¾

SAXONY.

Gold.

Name of Coin.	dwt.	gr.	£	s.	d.
Ducat	2	5¾	0	9	5
Double Augustus	8	13 11/12	1	12	11
Augustus	4	6 10/12	0	16	5½
Half Ditto	3	3 5/12	0	8	2¾

Silver.

Name of Coin.	dwt.	gr.	£	s.	d.
Rix-dollar Specie, or Convention, since 1763	18	1	0	4	1½
Half Ditto, or Florin	9	0½	0	2	0½
Thaler of 24 Groschen (imaginary coin)			0	3	1
Groschen	1	3⅓	0	0	1½

SICILY.

Gold.

Name of Coin.	dwt.	gr.	£	s.	d.
Ounce, 1748.	2	20½	0	10	10¼

Silver.

Name of Coin.	dwt.	gr.	£	s.	d.
Crown of 12 Tarins	17	14	0	4	0½

SPAIN.

Gold.

Name of Coin.	dwt.	gr.	£	s.	d.
Doubloon of 8 Crowns	17	9	3	4	8
——— of 4 Crowns	8	16½	1	12	4
——— of 2 Crowns	4	8¼	0	16	2
Half-pistol, or Crown	2	4⅛	0	8	1

Silver.

Name of Coin.	dwt.	gr.	£	s.	d.
Piaster	17	8	0	4	3¾
Real of 2, or Peseta, or one-fifth of a Piaster	3	18	0	0	10½
Real of 1, or Half Peseta, or one-tenth of a Piaster	1	21	0	0	5¼

SWEDEN.

Gold.

Name of Coin.	dwt.	gr.	£	s.	d.
Ducat	2	5	0	9	3¼
Half Ditto	1	2½	0	4	7⅛
Quarter Ditto	0	13¼	0	2	3¾

Silver.

Name of Coin.	dwt.	gr.	£	s.	d.
Rix-dollar of 48 shillings, from 1720 to 1802	18	17	0	4	6
Two-thirds of Rix-dol. of 32 schillings	12	11⅓	0	3	0
One-third, or 16 schillings.	6	5⅝	0	1	6

SWITZERLAND.

Gold.

Name of Coin.	dwt.	gr.	£	s.	d.
32 Franken piece	8	22	1	17	9
16 Ditto	4	11	0	18	10½
Ducat of Zurich	2	5¾	0	9	5
——— Berne	2	5⅓	0	9	2¾
Pistole of Berne	4	21	0	18	10

Silver.

Name of Coin.	dwt.	gr.	£	s.	d.
Crown of Basle	15	1	0	3	7¼
Half Crown, or Florin	7	12½	0	1	9¼
Franken of Berne, since 1803	4	17¼	0	1	2¼
Crown of Zurich	16	0	0	3	8½
Crown of Basle and Soleure since 1798	18	23	0	4	8
Piece of 4 Franken of Switzerland of 1803	18	23	0	4	9
Ditto of 2 Franken of Switzerland of 1803	9	11½	0	2	4½
Ditto of 1 Franken	4	17¾	0	1	2½

TURKEY.

Gold.

Name of Coin.	dwt.	gr.	English Value £	s.	d.
Zecchin Zermahboub of Sultan Abdoul Hamet	1	16	0	6	11
Half ditto	0	20	0	3	5½
Roubbié, or ¼ Zecchin Fondoukli	0	13⅞	0	1	11
Zecchin Zermahboub of Sel. III.	1	16	0	5	9½
Half Ditto	0	20	0	2	4¾
Quarter Ditto	0	10	0	1	2¼

Silver.

Name of Coin.	dwt.	gr.	£	s.	d.
Altmichlec of 60 Paras	15	50	0	2	9½
Yaremlec of 20 Paras, or 60 Aspres			0	0	9¼
Rouble of 10 Paras, or 30 Aspres			0	0	4½
Aspre, 120 in the Piastre					
Piastre of 40 Paras			0	1	7
Piece of 5 Piastres			0	2	3¼

TUSCANY.

Gold.

Name of Coin.	dwt.	gr.	£	s.	d.
Ruspone, 3 Zecchini, with the lily	6	17¼	1	8	7
One-third Ruspone, or Zecchino	2	5¾	0	9	6⅓
Half Zecchino	1	2¾	0	4	9
Zecchino with effigy	2	5¾	0	9	6⅛
Rosina	4	11½	0	17	1
Half Ditto	2	5¾	0	8	6½

Silver.

Name of Coin.	dwt.	gr.	£	s.	d.
Francesconi of 10 Paoli	17	13½	0	4	5¼
Piece of 5 Paoli	8	18¾	0	2	2½
——— 2 Paoli	3	6½	0	10	0
— 1 Paoli	1	15¼	0	0	5

VENICE.

Gold.

Name of Coin.	dwt.	gr.	£	s.	d.
Zecchino	2	5¾	0	9	6
Half ditto	1	2⅞	0	4	9
Ozella	8	19	1	17	4
Ducat	1	9⅞	0	5	11¼
Pistola	4	8½	0	15	11½

Silver.

Name of Coin.	dwt.	gr.	£	s.	d.
Ducat of 8 Livres	14	15⅓	0	3	3⅝
Crown of the Cross	20	10	0	5	3¼
Ducatoon	18	0	0	4	8
Talaro	18	13	0	4	2⅞

UNITED STATES OF AMERICA.

Gold.

Name of Coin.	dwt.	gr.	£	s.	d.
Double Eagle of 10 Dollars	11	6	2	3	9¾
Eagle of 5 Dollars	5	15	1	1	10½
Half Eagle of 2½ Dollars	2	19½	0	10	11¼

Silver.

Name of Coin.	dwt.	gr.	£	s.	d.
Dollar	17	10	0	4	3½
Half Dollar	8	17½	0	2	1¾
Quarter Dollar	4	8½	0	1	0¾

The copper coinage is almost entirely confined to the *cent*, which is worth rather more than the English halfpenny.

The following are the weights of the English coinage:

	oz.	dwt.	gr.
Sovereign	0	5	3.274
Half Sovereign	0	2	13.637
Double Sovereign	0	10	6.549
Five Sovereign	1	5	16.370
Sixpence	0	1	19.7-11ths
Shilling	0	3	15.3-11ths
Half-Crown	0	9	2.2-11ths
Crown	0	18	4.4-11ths

MONOCHORD, an ancient instrument, or machine, so called because it is furnished with only one string. Its use is to measure and adjust the ratios of the intervals, which it effects by the means of movable bridges, calculated to divide the chord at the pleasure of the experimentalist. The *monochord* appears to have been in constant use with the ancients, as the only means of forming the ear to the accurate perception, and the voice to the true intonation, of those minute and difficult intervals which were then practised in melody.

MONOCHROME, in *ancient painting;* a painting with one single colour. This description of art is very ancient, and was known to the Etruscans. The first specimens of the art of painting were of one tint only, which was most commonly red, made either with cinnabar or minium. Instead of red, white paint was sometimes used. Quintilian says of Polygnotus, and Pliny of Zeuxis, that their performances of this kind were of the latter description. The antique tombs of the Tarquins, in the neighbourhood of Corneto, offer several figures painted in white upon a dark ground. The first four plates in the first volume of the paintings of Herculaneum contain several monochromes upon marble. The most numerous monuments existing of this kind of painting are on terra cotta.

MONOLITHIC; consisting of a single stone. According to Herodotus, there was a monolithic sanctuary attached to a temple at Sais, dedicated to Minerva, twenty-one cubits long, fourteen wide, and eight high, which was brought from Elephantine. The carriage of it employed 2000 men three years. Some striking specimens of monolithic temples are still found in Egypt, and, like the monolithic obelisks, bear testimony to the wonderful application of mechanical power among the ancient Egyptians.

MONOPOLY is an exclusive right, secured to one or more persons, to carry on some branch of trade or manufacture, in contradistinction to a freedom of trade or manufacture enjoyed by all the world, or by all the subjects of a particular country. The most frequent monopolies formerly granted in Europe were the right of trading to certain foreign countries, the right of importing or exporting certain articles, and that of exercising particular arts or trades in certain towns or boroughs. These species of monopoly are now generally understood to be injurious. They still subsist, however, to a very considerable extent in Europe, but they have never been introduced into the United States of America. There is, however, one species of monopoly sanctioned by the laws, not only of that country, but of all countries that have made any advances in the arts, namely, the exclusive right of an invention or improvement for a limited number of years. The exclusive right of an author to the publication of his own work is hardly a monopoly, but rather a right of property, resting upon the same principle as the right to lands or chattels. The law, therefore, by giving an author the exclusive right to the publication of his own work, for a limited number of years, makes no grant; it is only allowing him what is his own, for a limited time. But the exclusive right to the use of an invention or improvement is a monopoly, since it deprives others, for that period, of the chance of the advantage of making the same improvement, discovery, or invention themselves. It is taking away a right which they before had.

MONSOONS; periodical trade-winds, which blow six months in one direction and the rest of the year in an opposite one. They prevail in the Indian Ocean, north of the tenth degree of south latitude. From April to October, a violent south-west wind blows, accompanied with rain; and from October to April a gentle, dry, north-east breeze prevails. The change of the winds, or the *breaking up* of the monsoons, as it is called, is accompanied by storms and hurricanes. These periodical currents of winds do not reach very high, as their progress is arrested by mountains of a moderate altitude. (See WINDS.)

MONSTERS, in *physiology;* creatures whose formation deviates in some remarkable way from the usual formation of their kind. The deviation consists sometimes in an unusual number of one or several organs; sometimes, on the contrary, in a deficiency of parts; sometimes in a malformation of the whole or some portion of the system, and sometimes in the presence of organs or parts not ordinarily belonging to the sex or species. In most cases, these unusual formations are not incompatible with the regular performance of the natural functions, although they sometimes impede them, and in some cases are entirely inconsistent with the continuance of the vital action. It is not surprising that we should be ignorant of the manner in which monsters, or irregular births, are generated or produced; though it is probable that the laws by which these are governed are as regular, both as to cause and effect, as in common or natural productions.

Formerly, it was a general opinion that monsters were not primordial or aboriginal, but that they were caused subsequently, by the power of the imagination of the mother transferring the imperfection of some external object, or the mark of something for which she longed and with which she was not indulged, to the child of which she was pregnant, or by some accident which happened to her during her pregnancy. But this has been disproved by common observation, and by philosophy: not perhaps by positive proofs, but by many strong negative facts; as the improbability of any child being born perfect, had such a power existed; the freedom of children from any blemish, though their mothers had been in situations most exposed to objects likely to produce them; the ignorance of the mother of any thing being wrong in the child, till, from information of the fact, she begins to recollect every accident which happened during her pregnancy, and assigns the worst or the most plausible as the cause; the organization and colour of these adventitious substances; the frequent occurrence of monsters in the brute creation, in which the power of the imagination cannot be great; and the analogous appearances in the vegetable system. Judging, however, from appearances, accidents may perhaps be allowed to have considerable influence in the production of monsters of some kinds, either by actual injury upon parts, or by suppressing or deranging the principle of growth, because, when an arm for instance is wanting, the rudiments of the deficient part may generally be discovered.

MONTGOLFIER BALLOON. This ingenious species of aëronautic machine appears better fitted for the purpose of navigating the air than the balloon usually employed, as it is less costly and more manageable than the hydrogen gas balloon. Under the article AERONAUTICS we have the history of its inven-

tion, and it only remains to point out its peculiar advantages.

The montgolfier or fire balloon, of which we give a graphic representation, owes its property offloating in the atmosphere to the rarefying power of heat applied to the air contained within. There is a vulgar error that the "smoke renders the balloon buoyant·" that, however, is not the fact, as the carbon of which the smoke is really composed is specifically heavier than the atmosphere. From this will be seen the impolicy of employing those combustible bodies which make much smoke. With common care on the part of the aëronaut, there is no real danger of the balloon igniting, as the air contained within, being deprived of its oxygen, might extinguish combustion, but would never produce it.

In a common hydrogen gas balloon the aërostat is made to ascend by discharging ballast, and descend by allowing the gas to escape. Now these processes will cease to operate for want of the necessary materials after one or two ascents; but with the montgolfier balloon a traveller may ascend by a slight addition to his fuel, or descend by lowering the fire, any number of times. With this control over the balloon, advantage may be taken of currents at different heights in the air, and the whole apparatus thus rendered much more manageable than it is usually found. The cloth should of course be rendered incombustible by some saline solution.

Month; the twelfth part of the year, and so called from the moon, by whose motions it was formerly regulated, being properly the time in which the moon runs through the zodiac. The lunar month is either illuminative, periodical, or synodical.

The *illuminative month* is the interval between the first appearance of one new moon and that of the next following. As the moon appears sometimes sooner after one change than after another, the quantity of the illuminative month is not always the same. The Turks and Arabs reckon by this month. A *lunar periodical month* is the time in which the moon runs through the zodiac, or returns to the same point again, the quantity of which is 27 d. 7 h. 43′ 8″. A *lunar synodical month*, called also a *lunation*, is the time between two conjunctions of the moon with the sun, or between two new moons, the quantity of which is 29 d. 12 h. 44′3″11‴. The ancient Romans used lunar months, and made them alternately of twenty-nine and thirty days. They marked the days of each month by three terms, *calends*, *nones*, and *ides*.

The *Solar month* is the time in which the sun runs though one entire sign of the ecliptic, the mean quantity of which is 30 d. 10 h. 29′ 5″, being the twelfth part of 365 d. 5 h. 49′, the mean solar year. The *astronomical* or *natural month* is that measured by some exact interval, corresponding to the motion of the sun or moon; such are the lunar and solar months above mentioned. The *civil* or *common month* is an interval of a certain number of whole days, approaching nearly to the quantity of some astronomical month. These may be either lunar or solar. The *civil lunar month* consists alternately of twenty-nine and thirty days. Thus will two civil months be equal to two astronomical ones, abating for the odd minutes; and so the new moon will be kept to the first day of such civil months, for a long time together. This was the month in civil or common use among the Jews, Greeks, and Romans, till the time of Julius Cæsar. The *civil solar month* consisted alternately of thirty and thirty-one days, excepting one month of the twelve, which consisted only of twenty-nine days, but every fourth year of thirty days. The form of civil months was introduced by Julius Cæsar. Under Augustus, the sixth month (till then, from its place, called *Sextilis*) received the name *Augustus* (now *August*), in honour of that prince; and, to make the compliment still greater, a day was added to it, which made it consist of thirty-one days, though till then it had only contained thirty days, to compensate for which a day was taken from February, making it consist of twenty-eight days, and twenty-nine every fourth year. Such are the civil or calendar months now used throughout Europe.

Monument. The productions of sculpture and architecture, intended to transmit to posterity the memory of remarkable individuals or events, are most generally understood by the term monuments of antiquity. Such as ornament public places, gardens, &c., are chiefly in commemoration of great events. Among the monuments in honour of individuals are tombs and sepulchral edifices or columns. In all ages, and with every nation, we find this description of monument, from the first rude attempts of art to its greatest perfection. The most ancient known to us are the obelisks and pyramids of Egypt, and, perhaps contemporary with these, the tombs of the Persian kings, which are still beheld with admiration in the ruins of Persepolis. These monuments command our awe by their grandeur and simplicity, in which they are perhaps superior to similar works of Grecian art, though the latter excel them in beauty. Hardly any country offered so great a number of monuments as Greece, where they were erected in honour of the victors in battle, and in the solemn games, and of other distinguished men, but were often also thrown away on the undeserving. The warrior had statues and trophies; the victor in the games had statues

and pillars. On the isthmus of Corinth, near the temple of Neptune, were statues of the victors in the Isthmian games; in the holy grove of Altis, near Olympia, were those of the victors in the Olympic games. There were also many trophies. Buildings were frequently erected in commemoration of distinguished persons or events, which differed greatly in form and splendour. Thus, in Athens, the choragic monuments were erected in honour of those who had received the prizes as *choragi* in the theatrical and musical games. In these games it was customary for each of the ten guilds of Athens to select one *choragus*, who, at his own expense, undertook the regulation and superintendence of the games. Each endeavoured to surpass the other; the conqueror received a tripod of brass as the prize, which was usually the work of a great artist, and was regarded as an honour to his family. This prize was publicly placed on a small edifice or a single pillar, on which the name of the *choragus* and the date of the games were inscribed. A particular street in Athens, called the street of *tripods*, was appropriated to these monuments. Some of these have been preserved to our time. The most splendid of all, and the most ornamented, is the choragic monument of Lysicrates, usually called the *lantern of Demosthenes;* next to this are the monuments of Thrasyllus and Thrasycles, and some pillars. The Romans, who contended with the Greeks in the arts, were equally successful in monuments, of which one species (the triumphal arch) is entirely theirs. (See TRIUMPHAL ARCH.)

The earliest tombs in Greece and Rome were erected either on the spot where the ashes of the deceased were deposited or in some other place chosen at pleasure. These latter were termed *cenotaphs.* Both kinds were found in the cities or their vicinity, and scattered along the roads, which they ornamented. The rude stone was by degrees transformed into a noble pillar; subsequently, on a foundation of stone, two small pillars were erected, covered with a pediment, and the intermediate space was destined for the image of the deceased, inscriptions, and bass-reliefs. Small buildings in the form of temples followed, and these, in time, increased in magnificence. (SEE TOMB.)

MOON is the name given to the satellites which revolve round the primary planets and illuminate them with light reflected from the sun. In common language, we mean by *moon* the particular satellite of our earth. Like the other heavenly bodies, it daily alters its apparent position among the fixed stars, and in the course of a month appears to make a complete revolution round the heavens, from west to east, while, at the same time, it has, like the fixed stars, an apparent daily motion from east to west. Among all the heavenly bodies, the moon is the nearest to us. Its mean distance is estimated at about thirty times the diameter of the terrestrial equator, or 237,000 miles. The point at which it approaches nearest the earth is called its *perigee;* the point of its greatest distance is called the *apogee.* It passes through both these points in each revolution. According as it is nearer to or further from the earth its diameter, as seen from the earth, appears larger or smaller. In the moon's revolution great inequalities are remarked. These arise mostly from the strong attraction of the sun in the various positions which it assumes relatively to the earth. This was first understood after Newton's discovery of the universality of the law of gravity. Tobias Mayer published the first accurate lunar tables. Besides the double motion of the moon round our earth, and with the earth round the sun, it also revolves on its own axis. It completes a revolution on its own axis in the same time with its revolution round the earth, as appears from its always presenting the same side to the earth. In consequence of this remarkable coincidence, the earth must appear to a spectator on the moon to be always in the zenith. One side of the moon, moreover, never receives the reflection of the sun's rays from the earth, while the other is constantly illuminated by it; both sides, however, are equally illumined by the direct rays of the sun. Some little irregularity has been perceived in the surface of the moon presented to the earth, its spots sometimes appearing more to the north, at others more to the south; a similar variation is perceived east and west. This phenomenon is denominated the *libration* of the moon in latitude and longitude. The causes of both have been discovered.

Of all the heavenly bodies, the moon, from its comparative proximity to the earth, is the one of which most is known. That it is an opaque body, receiving its light from the sun, is evident from the phenomena of solar and lunar eclipses, but more particularly from the various phases which it presents. Even the naked eye discovers, on the illuminated surface of the moon, several spots, more or less bright; and a good telescope shows us in the bright parts, on the limits of illumination, prominences and depressions, which are regarded as mountains and valleys. The numerous observations of Herschel and Schröter, through a number of years, have put the existence of these beyond dispute. The large dark spots appear, when intersected by the frontier line of illumination, always even and without prominences. Hence they are supposed to be plains, consisting of a substance which has comparatively little power of reflecting the sun's rays. That they are seas is not probable, since Huygens observed great depressions in them, and Schröter, in several of these depressions, discovered evident traces of various horizontal strata, lying one upon the other, and forming a wall around them. Schröter, who measured several of these depressions, found their diameter to be from thirty feet to more than half a mile; the diameter of one, in fact, was more than sixteen miles, and its depth 30,000 fathoms.

The shepherd Endymion, according to Pliny, first observed the course of the moon and its changes. Hence the story of Endymion and Diana. Even the Chaldeans considered the moon as the smallest among the heavenly bodies and the nearest to the earth; they knew that her light was borrowed, fixed her periodical phases with much accuracy, and attributed her eclipses to the shadow of the earth. That the moon was inhabited was conjectured by Orpheus, or rather by the author of the verses which exist under his name; and Pherecydes of Scyros, a contemporary of Servius Tullius, is said to have determined the time of her revolution. The Pythagoreans affirmed that the moon contained mountains, cities, plants, animals, and men. Anaximander knew the size of the moon, its distance from the earth, and that its light was borrowed from the sun. The spots on its surface Clearchus considered to be seas.

In modern times, this planet has occupied much of the attention of astronomers. Doctor Francis von

Paula Gruithuisen, professor of astronomy at Munich, has, of late years, paid great attention to the moon, and his discoveries and hypotheses, though wanting confirmation, have excited much interest. In his opinion, the straight lines, often of considerable length and a parallel direction, which have been observed on its surface, and which are made up of objects resembling in shape a star, an inverted Z, &c., are, in fact, roads, with cities, temples, dwellings, &c. At present, however, these conjectures can hardly be regarded as more than the creations of a lively imagination. (See ASTRONOMY.)

MORAL PHILOSOPHY. See PHILOSOPHY.

MORDANTS. The colouring substances used in dyeing have been divided by Doctor Bancroft into *substantive* and *adjective* colours. *Substantive* colours are those which communicate their tint immediately to the material to be dyed, without the aid of any third substance. *Adjective* colours require the intervention of a third substance, which possesses a joint attraction for the colouring matter and the stuff to be dyed. The substance capable of thus fixing the colour is called a *mordant*, and by Mr. Henry a *basis*. (See DYEING.)

MOROXYLIC ACID; the name applied by Klaproth to an acid found in combination with lime, forming a blackish-brown coating, on the trunk of a white mulberry tree at Palermo. Its taste and other qualities approach nearest to those possessed by the succinic acid. It crystallizes in colourless transparent prisms, and is soluble in water and alcohol.

MORPHIA; a new vegetable alkali, extracted from opium, of which it constitutes the narcotic principle. It is obtained pure by the following process:—A concentrated infusion of opium is boiled with a small quantity of common magnesia for a quarter of an hour: a considerable quantity of a grayish deposit falls: this is washed on a filter with cold water, and when dry digested in weak alcohol for some time, at a temperature beneath ebullition. In this way, a little morphia and a great quantity of colouring matter are separated. The matter is then drained on a filter, washed with a little cold alcohol, and afterwards boiled with a large quantity of highly rectified alcohol. This liquid, being filtered while hot, on cooling, deposits the morphia in crystals, and very little coloured. The solution in alcohol and crystallization being repeated two or three times, colourless morphia is obtained. It crystallizes in double four-sided pyramids, whose bases are squares or rectangles; sometimes also in prisms, with trapezoidal bases. It dissolves in eighty-two times its weight of boiling water, and the solution, on cooling, deposits regular and colourless crystals. It is soluble in thirty-six times its weight of boiling alcohol, and in forty-two times its weight of cold alcohol. It dissolves in eight times its weight of sulphuric ether. All these solutions change the infusion of brazil-wood to violet, and the tincture of rhubarb to brown. According to M. Bussy, morphia consists of

Carbon	69.0
Hydrogen	6.5
Azote	4.5
Oxygen	20.0
	100.0

With acids it forms a class of salts in like manner as do the other vegetable alkalies. *Sulphate of morphia* crystallizes in prisms, which dissolve in twice their weight of distilled water. They are composed of

Acid	22
Morphia	40
Water	38
	100

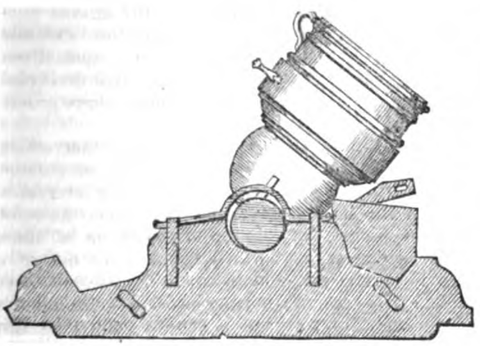
Nitrate of morphia yields needle-formed crystals in stars, which are soluble in one and a half times their weight of distilled water. *Muriate of morphia* is soluble in ten and a half times its weight of distilled water. The acetate crystallizes in needles, the tartrate in prisms, and the carbonate in short prisms. Tincture of galls is said to be a good test of morphia, free or combined. Subacetate of lead throws down all the animal matters with which acetate of ammonia may come to be associated in the stomach, without acting on that vegetable salt. The excess of lead may be separated from the clear liquor by a few bubbles of sulphuretted hydrogen; and the morphia may then be recognized by crystallization *in vacuo*, and by the red colour which nitric acid imparts to it. No morphia is found in the blood of animals killed with it. Morphia acts with great energy on the animal economy. A grain and a half, taken at three different times, produced such violent symptoms upon three young men of seventeen years of age, that Sertürner was alarmed lest the consequences should have proved fatal.

MORTALITY. The law of mortality is that which determines the proportion of the number of persons who die in any assigned period of life or interval of age, out of a given number who enter upon the same interval, and consequently the proportion of those who survive. Tables showing how many out of a great number of children, as 10,000 or 100,000, born alive, die in each year of their age, and consequently how many complete each year, and exhibiting this law through the whole extent of life, are called *tables of mortality*. The basis of such calculations must be an accurate register of the number of births and deaths, and, in the case of the latter, at what ages in a given district or extent of country. In England the bills of mortality, or abstracts from parish registers, show the numbers who are born and die in the different parishes; and in other countries similar mortuary registers are kept. The results furnished by such tables are very various, and of great interest.

If the registers were kept with sufficient accuracy and minuteness, they would enable us to determine the proportion of deaths, not only at different ages and in different regions, but at different seasons, in persons of different occupations and habits, in towns or in the country, and would afford valuable materials for the science of political economy. Although much more attention has been paid to this subject in recent times, yet the observations have not been so extensive nor so accurate as is desirable. The first table of mortality was constructed by Doctor Halley, from the mortuary registers of Breslau, for five years ending with 1691, and was inserted in his paper on the subject in the *Philosophical Transactions* for 1693, with many useful observations on the purposes to which such tables may be applied. (See LONGEVITY.)

MORTAR, in *gunnery*, is a kind of short cannon, of a large bore, with chambers. Mortars are made of stone, brass, or iron. Their use is to throw hollow shells filled with powder, which, falling on any building, or into

the works of a fortification, burst, and their fragments destroy every thing within reach; also balls of stone, carcasses, bags filled with grape-shot, &c. They were first used in sieges for throwing great balls of stone and of red-hot iron, before the invention of shells. On this account, the caliber of a mortar, in Germany, is generally estimated by the weight of a stone of the size of the bomb which it is intended to throw. In Denmark and Russia, on the contrary, the caliber is estimated by the actual weight of an iron ball fitting it; in this country and France, by its diameter in inches. In the larger states of Europe, 10, 16, 25, 30, 50, and 60 pound mortars, according to the stone weight measure, are used. In the Prussian army, 7, 10, 25, 50, 75 pound mortars are customary. Formerly they were used even of 120 lbs. weight; but these are not employed at present, except in particular cases. Their length is generally from 2¼ to 3½ times the diameter of the caliber. The best form of the mortar is shown beneath :—



The interior parts of a mortar are the chamber, the bore, the mouth, the vent. The chamber is the place where the charge of powder is lodged. The shape of the chamber varies. It is generally conical, more or less truncated. *Land mortars* are those used in sieges, and mounted on beds. The beds are made of very solid timber, and placed upon very strong timber frames. *Stone mortars* serve to throw stones into the enemy's works when near at hand. *Sea mortars* are those which are fixed in bomb-vessels for bombarding places by sea; they are made much longer and somewhat heavier than land mortars.

The use of mortars is thought to be older than that of cannon, for they were employed in the wars of Italy to throw balls of red-hot iron and stones long before the invention of shells. It is generally believed that the Germans were the inventors, and that they were used at the siege of Naples, in the reign of Charles VIII., in 1435. It is more certain that shells were thrown out of mortars at the siege of Wachtendonk, in 1588, by the count of Mansfield.

Mortar, in *building*. That species of earthy composition which is especially fitted to resist the action of water, or a damp climate, is described under the article Cement, and we now propose examining the cheaper forms known as mortar.

The mode of making the very durable material suggested by M. Loriot may be first described :— Take one part of brick-dust finely sifted, two parts of fine river-sand skreened, and as much old slaked lime as may be sufficient to form mortar with water in the usual method, but so wet as to serve for the slaking of as much powdered quick-lime as amounts to one-fourth of the whole quantity of brick-dust and sand. When the materials are well mixed, employ the composition quickly, as the least delay may render the application of it imperfect or impossible. With respect to this method, Dr. Higgins observes that M. Loriot corrects the bad quality of the old and effete lime, which constitutes the basis of his mortar, and which has regained a part of the fixed air that had been expelled from it, by the addition of fresh and non-effervescent lime, hastily added to it at the time of using the composition, which must undoubtedly improve the imperfect mass. According to Dr. Higgins, the perfection of lime prepared for the purpose of making mortar consists chiefly in its being totally deprived of its fixed air. On examining several specimens of the lime commonly used in building, he found that it was seldom or never sufficiently burnt, for they all effervesced, and yielded more or less fixed air, on the addition of an acid, and slaked slowly in comparison with well-burnt lime. Dr. Higgins also relates some experiments which show how very quickly lime imbibes fixed air from the atmosphere, on its exposure to which it by degrees soon loses those characters which chiefly distinguish it from mere lime-stone or powdered chalk, by soon attracting from thence that very principle to the absence of which it owes its useful quality as a cement, and which had before been expelled from it in the burning. Hence he concludes that, as limes owes its excellence to the expulsion of fixed air from it in the burning, it should be used as soon as possible after it is made, and guarded from exposure to the air as much as possible before it is used. It is no wonder, therefore, he says, that London mortar is bad, if the imperfection of it depended solely on the badness of the lime; since the lime employed in it is not only bad when it comes fresh from the kiln, because it is insufficiently burnt, and the air has access to it, but becomes worse before it is used, by the distance and mode of its conveyance, and when slaked is as widely different from good lime as it is from powdered chalk. For a similar reason, every other cause which tends to restore to the lime the fixed air of which it had been deprived in the burning must depreciate it.

It must receive this kind of injury, for instance, from the water, so largely used, first in slaking the lime, and afterwards in making it into mortar, if that water contains fixed air, from which few waters are perfectly free, and which will be greedily attracted by the lime. The injury arising from this cause is prevented by the substitution of lime-water, so far as it may be practicable or convenient.

From other experiments, made with the view of ascertaining the best relative proportions of lime, sand, and water, in the making of mortar, it appeared that those specimens were the best that contained one part of lime in seven of the sand; for those which contained less lime, and were too short whilst fresh, were most easily cut and broken, and were pervious to water; and those which contained more lime, although they were closer in grain, did not harden so soon, or to so great a degree, even when they escaped cracking by lying in the shade to dry slowly. It appeared, further, that mortar which is to be used where it must dry quickly ought to be made as stiff as the purpose will admit, or with the smallest

practicable quantity of water, and that mortar will not crack, although the lime be used in excessive quantity, provided it be made stiffer or to a thicker consistence than mortar usually is.

Dr. Higgins has also shown that though the setting of mortar, as it is called by the workmen, chiefly depends on the exsiccation of it, yet its duration, or its acquiring a stony hardness, is not caused by its drying, as has been supposed, but is principally owing to its absorption of fixed air from the atmosphere, and is promoted in proportion as it acquires this principle, the accession of which is indispensably necessary to the induration of calcareous cements. In order to the greatest induration of mortar, therefore, it must be suffered to dry gently and set; the exsiccation must be effected by a temperate air, and not accelerated by the heat of the sun or fire; it must not be wetted soon after it sets; and afterwards it ought to be protected from wet as much as possible, until the mortar is finally placed and quiescent; and then it must be as freely exposed to the open air as the work will admit, in order to supply acidulous gas, and enable it sooner to sustain the trials to which mortar is exposed in cementing buildings, and other incrustations.

Dr. Higgins also enquired into the nature of the best sand or gravel for mortar, and into the effects of bone-ashes, plaster, powder, charcoal, sulphur, &c., and he deduces great advantages from the addition of bone-ashes, in various proportions, according to the nature of the work for which the composition is intended.

Fresh-made mortar, if kept from the air under ground in considerable masses, may be preserved a great length of time without injury, and the older it is before it is used the better, the builder taking the precaution to beat it up afresh previous to using it; for it not only sets sooner, but acquires a greater degree of hardness, and is less apt to crack. A fact related by Mr. Smeaton remarkably illustrates these points. Having had occasion to take up a large flat stone of a close grain, of about five feet square, that had probably lain above a century at the bottom of a malt cistern, he found that it had been well bedded in mortar, which had become coagulated to the consistence of cheese; but, having never come to a perfect dryness, it so far retained its natural humidity that he found it might, with some pains, be beaten up to mortar without any addition of water; and afterwards, being suffered to dry in the air, it set to a stony hardness, and appeared as good mortar as any which that part of the country could produce. Pliny informs us that the ancient Roman laws prohibited builders from using mortar that was less than three years old; and to this circumstance he expressly attributes the remarkable firmness of the oldest buildings in the city. A similar custom prevailed, and indeed still prevails, in Vienna, requiring the mortar to be a year old before it is employed. But there is nothing which shows, in so striking a point of view, the advantage and necessity of beating mortar (and the effect produced is owing to something more than a mere mechanical mixture of ingredients) as the preparation of grout, or liquid mortar. This differs from common mortar only in containing a larger quantity of water, so as to be sufficiently fluid to penetrate the narrow irregular interstices of rough stone walls, and is generally made by diluting common mortar with water, either cold or hot. It not unfrequently happens that this refuses to set, and at all times it is a long while in acquiring the proper hardness; but if, instead of common mortar, that which has been long and thoroughly beaten is employed, the grout will set in the space of a day, and soon after acquires a degree of hardness much superior to what is made in the common manner.

Mortar which sets without cracking, whether this be owing to the due proportion of sand or to the slow exhalation of the water from mortar containing less sand, never cracks afterwards, whatever its faults, in other respects, may be. As it is the lime paste, and not the sand, which contracts and produces fissures in drying, so the more sand there is in the composition, the less the cracks will be seen. Mortar which is liable to crack becomes irreparably injured by frequent alternations of wetting and freezing; for the water imbibed by the smallest fissures, dilating as it congeals, loosens its whole texture. Where, however, it is composed of seven parts of sorted sand to one of lime, it is not disposed to crack.

To show more clearly how much our slight buildings are weakened by the agitations and percussions to which they are exposed, first in erecting the walls and settling the timbers, and then in driving those wedges to which the wainscots, mantlepieces, and other ornaments, are fastened, we must observe that the absorption of carbonic acid by mortar contributes nothing to the strength of it, if it enter before it is finally fixed in a quiescent state. A little experience is sufficient to teach us that the same matter which assists in the induration of mortar never serves to repair the fissures, or solution of continuity between the bricks and cement, which happen after it is set. When mortar is set, and before it is indurated, it may be easily severed from the bricks and crumbled; and, for want of softness, it cannot bend into the fissures, or resume its former condition in any time. Hence, by heavy blows, and in wedging, our walls must be greatly weakened; and the more so as the houses are slight, quickly built, and hastily finished.

Nothing is more common than for bricklayers to keep their mortar some time exposed to the air in heaps, before they consider it fit for use, a practice which may perhaps be accounted for if we consider that some portions of every kind of lime used in this country do not slake freely, by reason of their not being sufficiently burned, or the admixture of gypseous or argillaceous matter, which portions, like marl, slake in time, though not so quickly as the purer lime. The plasterers, who use a finer kind of mortar, made of sand and lime, observe that their stucco blisters if it contains small bits of unslaked lime; and, as smoothness of surface is with them of more consequence than excessive hardness, they take care to secure the perfect slaking of their lime by allowing sufficient time for the imperfect parts to be penetrated by the moisture. The bricklayers, trusting perhaps more to the judgment of the plasterers, in this respect, than to their own, and considering it very convenient to slake a large quantity of lime at once, follow the same practice, without caring for or apprehending the real fact, that mortar, when exposed to the air, is worse for every hour it is kept, and that they are taking such measures as will prevent it from ever acquiring that degree of hardness in which its perfection consists.

Among the circumstances which contribute to the speedy ruin of modern buildings, it may also be

observed that mortar made with bad lime, and a great excess of it, is used with dry bricks, and not unfrequently with warm ones. These immediately imbibe or dissipate much of the water; and, as the cement approaches nearer to dryness, it is still liable to be displaced by the percussions of the workmen. To make strong work, the bricks ought to be soaked in lime-water, and freed from the dust with which they are commonly covered. By this means the bricks are rendered closer and harder, the cement, by setting slowly, admits the motion which the bricks receive when the workman dresses them, without being impaired, and it adheres and indurates more perfectly. This steeping of the bricks is an imitation of the practice of the plasterers, who always wet the wall before they commence their work, because they know the cement will not otherwise adhere. This ought to be done as long as the wall is thirsty, and lime-water is the most proper liquid they can use. The same advantage that attends the soaking of bricks would attend the soaking of bibulous stones in lime-water.

Mortification, in *medicine*, is the death of a part of the body while the rest continues alive, and often in a sound state. If the part be a vital organ, as the lungs, its death must necessarily be followed by that of the whole person. Mortification is called *gangrene* and *sphacelus*, when occurring in soft or fleshy parts, as in the stomach or the limbs; and *caries* when in a bone, as in the spine, in the skull, &c. It is caused by violent inflammation, by exposure to freezing cold, by hospital fevers, by languid, or impeded, or stopped circulation, as in cases of bed-ridden or palsied persons, and by improper food, particularly the spurred or mildewed grain. It may be recognized, when preceded by inflammation, by the following signs:—subsidence of pain, heat and redness, and loss of sensibility; brown lividity, blistered skin with bloody serum in the vesicles, offensive odour occurring in the part, and by a small, rapid, intermitting pulse; by shiverings followed with cold sweat, diarrhœa, delirium, hickup, dejection of spirits, and by a wild cadaverous countenance. When a part which has been frozen is suddenly exposed to heat, mortification rapidly ensues; the part becomes florid; inflammation is unsuccessfully attempted, and sphacelus is the result. In the above species a distinctly marked line divides the dead and living portions; often a healthy separation ensues.

Mortification is common in the fevers, wounds, and injuries of the crowded jails and military hospitals of Europe. This gangrene is considered contagious by some surgeons, the nurses and orderlies suffering from ulcers and sloughs on the hands, when touched with the sponges used in cleansing the sick. The same effect is produced on the sound portions of the skin of the sick. This hospital gangrene is distinguished by its rapid spread to contiguous parts, as from the fingers to the arms, by the oozing of grumous blood, by horrible fetor, by fatal depression of spirits, and by the sullen despair of patients who on the day of battle or of amputation were the bravest of the brave. Sometimes the cutting a nail to the quick, or a slight bruise, will induce gangrene in old or debilitated persons.

Mildew mortification differs from other kinds in appearance and process, beginning with coldness and numbness in the fingers or toes without fever, but with spasms and hebetude of mind; it separates arms, legs or thighs, and nose. It is more often found in the voluptuous rich than in the labouring poor, in huge feeders than in free drinkers. It is thought to be connected with a diseased state of the digestive organs, and great nervous debility. Mr. Pott sometimes checked it by opium in a few days, and, after the dropping off of the affected parts, the patients recovered health. There is a dry gangrene to which palsied persons as well as others are liable, which slowly destroys the limb, and commonly without inflammation or putrefaction. This is sometimes explained by the absence of warmth, and moisture, and air, which are removed by preceding atrophy: the colour is livid, though sometimes nearly natural. When the bones of the leg mortify or become carious, new osseous matter is provided in sound constitutions. This process, occupying years when left to nature, is much accelerated by the artificial removal of the dead bone.

Mosaics are imitations of paintings by means of coloured stones, pieces of glass, of marble, and even of wood of different colours, cemented together with much art. The name is sometimes supposed to be derived from *Moses*, as the pretended inventor; sometimes from *Musa*, in the sense of elegance, beauty; and sometimes from *μουσειον*, museum (a grotto consecrated to the muses), perhaps from the circumstance that mosaic work was first used in grottoes. We know nothing with precision of the invention and history of this art in antiquity. Probably it originated in the East, but received its perfection from the Greeks, and was thus conveyed to the Romans in Sylla's time. In Italy, and in most of the countries occupied by the Romans, many floors ornamented with mosaic work have been found amongst the ruins. When, in the fifth century, the arts and sciences were driven from Italy by the distracted state of the country, this art was preserved by the Byzantine Greeks, and was restored to Italy in the thirteenth century, where it attained the highest perfection, particularly when Clement VIII., at the commencement of the seventeenth century, had the whole of the interior of the dome of St. Peter's ornamented with this work. Giambattista Calandra improved mosaic by the invention of a new cement. He and many succeeding artists employed the art for copying original paintings of famous artists, and thus eternizing them in their original freshness and beauty; for one of the greatest advantages of this kind of painting is its wonderful power of preservation. In this manner Guercino's Martyrdom of St. Petronilla, and Dominichino's Communion of the dying St. Jerome, were preserved. Peter Paul, of Christophoris, founded, at the commencement of the eighteenth century, a school for mosaic in Rome, and many of his scholars carried the art to a still higher degree of excellence.

In recent times two kinds of mosaic are particularly celebrated,—the Roman and the Florentine. In the former the paintings are formed by joining very small pieces of stone, which gives greater variety and elegance, and facilitates the representation of large historical paintings. The Florentine style, which makes use of larger pieces of stone, is far more troublesome, and is adapted only for simple subjects.

Mosaic in wood the Italians call *tansia* or *tarsia;* the French *marqueterie*. In the most costly mosaics, precious stones have been cut to furnish materials; but in common works of this art enamels of different

colours, manufactured for the purpose, are the material employed. The enamel is first formed into sticks, from the ends of which pieces of the requisite size are cut or broken off. These are confined in their proper places upon a plate of metal or stone, by a cement made of quicklime, pulverized limestone, and linseed oil. The cement is spread over the plate, and a drawing made on it to guide the artist, before he commences his work. He has also constantly before him the painting to be copied. After the whole has adhered it is allowed to dry for two months, and is then polished with a flat stone and emery. Inlaid works, of agate and other costly stones, are executed on the same principle as mosaic, except that the stones are cut to the shape of the different parts of the object to be represented, whereas in mosaic the pieces are of the same size and shape.

The *opus reticulatum* of the ancients, with which columns and walls were sometimes incrusted, is found to consist of small stones of a pyramidal form, the apex of which is imbedded in mortar, while the base which is polished forms the outer surface. A mode has recently been invented of sawing the plate with the mosaic paintings into two or three sheets, and thus multiplying the paintings. Should smoke or dirt soil the surface, it has only to be polished to be restored to its original beauty. In 1819, Fernbach, a native of Baden, invented a new kind of mosaic painting, imitating with surprising fidelity the colour, the juncture, the lustre, &c., of mineral bodies. Professor Blank's mosaics of moss have also attracted much attention.

Moselle Wines; a sort of clear and dry wines, with a light pleasant flavour and high aroma, produced in the countries on and near the Moselle. They are generally only first-rate ordinary wines, but are sometimes of a superior quality. They come to maturity in about five or six years, but, in a favourable season, they will keep twice that time without deterioration. The best are produced at Braunenberg, Graach, Wehlen, Zeltingen. The Drobner and Neumanger are also esteemed. They are now much used in Prussia, on account of the high duties on foreign wines. The Moselle wines are often recommended for their diuretic qualities.

Motet formerly signified a studied composition, enriched with all the beauties of the musical art. At present, the name of *motet* is given to every composition set to Latin words; such as hymns, psalms, or any small portion of scripture, in the Roman Catholic church. In Germany the name is given to figured musical pieces, generally intended only for singing, the subjects of which are passages of the Bible. There are some for four, five, and six voices. The motets of France and Italy are always accompanied by instrumental music. The subjects are also passages of the Bible, generally in rhymed Latin verses, whilst the words of the German *motet* are in prose. The German *motet* is chiefly confined to the Protestant part of Germany. The two Bachs may be said to have carried the German *motet* to its highest perfection.

Motion. The motion of a body is the change of its place in space. All changes in the material world consist of motion. The life of the organic creation and the action of inorganic bodies consist in motion: what we call *rest* is only relative. Experience alone convinces us of the motion of bodies in space. Zeno of Elea endeavoured to prove this fundamental idea of motion to be contradictory to itself, in order to overthrow the testimony of experience. If we see that a body changes its external relations, we conclude that it moves: its continuance in the same relations is called *rest*. By a change of the situation or relation of bodies we are often deceived, and confound *rest* with *motion*. In some cases it is easy to perceive the error; in others it is so difficult that many centuries have been necessary to dispel the illusion; for instance, in relation to the earth and the sun.

In motion, we must consider the cause, the moving body, the direction, the path described, the time, the velocity, and the quantity. The mass of the moving body must be taken into consideration, since the quantity of motion depends on the quantity of matter. To move twice as much matter requires twice as much power. The direction of the motion of a body is the line along which a moving point proceeds, either for the whole or a part of the way. If all the points of a body move in the same direction it is only necessary to observe the motion of a single point. The line described by this point is the path of the moving body. This path itself, if in a straight line, represents the direction of the motion; if in a curved line, the direction at every point of the curve is determined by the tangent to this point; that is, this tangent shows the direction of the moving body at that point in which it would continue to proceed if it ceased changing its direction. If all the points of a body do not move in the same direction, the motion of each point in particular ought to be observed; and thus we may consider every motion as the motion of a point. By the space described, we understand the distance passed through by the moving point. Since we always consider the motion of points, this space is represented by a line; and thus the observation of motion becomes geometrical. Time is necessary for motion, even for the smallest. By the comparison of the space described, and the time in which it is described, we find the velocity. One body moves quicker than another if it describes in the same time a larger space, or the same space in a less time.

By the *quantity of motion* we mean the velocity combined with the quantity of matter. To move two pounds requires twice as much power as to move one pound with the same velocity. To move a body with the velocity 2 also requires twice as much power as to move the same body with the velocity 1. Hence it follows that to move two pounds with the velocity 3 requires six times as much power as to move one pound with the velocity 1. Motion may be considered under several different views. With regard to change of position, by which it is ascertained, it is either *absolute* or *relative*. If a body passes from one place to another, this is called *absolute motion*; it is *relative* if we consider the objects to which we refer the motion of the observed body, whether in motion or at rest, as fixed points. With regard to change of position the motion is further either *common* or *proper*; finally, either *apparent* or *real*. With regard to the powers or causes which produce motion, it is either *simple* or *compound*: *simple* if it is produced by a single power, or by several powers acting in the same direction; *compound* if several motions meet, the various directions of which form angles with each other. With regard to the direction, the motion is either in a *straight* or a *curved* line; with regard to the velocity, it is

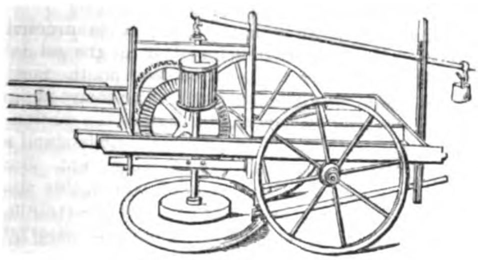
uniform, or *accelerated*, or *retarded*, and the accelerated motion again is either uniformly or variably accelerated; and the retarded motion either uniformly or variably retarded.

MOULDING. See ARCHITECTURE.

MOUND, in *heraldry*; a globe, having a cross on the top. Many heraldic eagles, as those of Austria, Russia, Prussia, have in one claw the sceptre, in the other the mound.

MOUTH; in most animals, a cavity in the anterior part of the body, but very differently formed in different sorts of animals. It commonly serves for the reception of food, and is connected by a canal with the interior parts of the body, where the food is assimilated. In the higher orders it is used for mastication, the emission of sound, deglutition, respiration, suction, and taste, being connected with organs which perform those processes. The lower jaw only is movable in this division. Some of the lower orders seem to be without a mouth, and to nourish themselves by absorption. In birds, the external parts of the mouth are a hard, bony substance, and it is not fitted for suction. In insects, the form of the mouth is very various.

MOWING MACHINE; an instrument by which a series of knives or scythes are made to perform the office of *human* power.



One of the most simple of these machines is represented above. It is intended to be driven by a single horse placed behind the carriage, and as the supporting wheels roll forward they act on a series of wheels and pinions, so as to drive forward the knives. The height of the horizontal cutting-wheel is regulated by a lever and weight, placed in the front of the machine.

Machinery, when applied to this and similar purposes, should be introduced but slowly, and with great caution. In manufacturing districts, there are new sources of employment continually arising from the artificial wants of society; but the hasty introduction of agricultural machinery, by displacing a large portion of the rural population, produces the most mischievous consequences. No one can doubt the truth of the axiom, that the man who causes two blades of grass to grow where but one vegetated before must be a great benefactor to mankind; but such a result will not be produced by machinery: on the contrary, we find that in many soils the plough has been advantageously laid aside and spade husbandry resorted to. (See PLOUGH.)

MOXA; a soft lanuginous substance, prepared from the young leaves of a species of mugwort. It is used by the surgeons in the following way:—A little cone of the moxa is laid upon the diseased part, previously moistened, and set on fire at the top. It burns down with a temperate glowing heat, and produces a dark-coloured spot, the separation of which is promoted by applying a little garlic. The ulcer is left to discharge, or is healed up, according to the object in view. The moxa is famous in the East for curing several diseases, and the French are much in the habit of using it; but, whenever English surgeons wish to produce a slough, they have recourse to caustics, in preference to actual fire.

MUCIC ACID; this acid has generally been known by the name of *saccholactic* acid, because it was first obtained from sugar of milk; but all the gums appear equally to afford it. To obtain it from a gum, we have only to heat one part of this substance with two of nitric acid, till a small quantity of nitrous gas and of carbonic acid is disengaged, when the dissolved mass will deposit, on cooling, the mucic acid. The pulverulent acid is soluble in about sixty parts of hot water. It decomposes the muriate of barytes, and both the nitrate and muriate of lime. It scarcely acts upon the metals, but forms salts with their oxides.

MUCUS; one of the primary fluids of the animal body, perfectly distinct from gelatin and vegetable mucus; transparent, glutinous, thready, and of a salt savour. It contains water, muriate of potassa, soda, lactate of lime and of soda, and phosphate of lime. The mucus forms a layer of greater or less thickness at the surface of the mucous membranes, protects these membranes against the action of the air, of the aliment, the different glandular fluids, &c. Independently of this general use, it has others that vary according to the situation of the mucous membranes: thus the mucus of the nose is favourable to smell, that of the mouth to the taste; while that of the stomach and the intestines assists in the digestion. A great part of the mucus is absorbed again by the membranes which secrete it: another part is carried outwards, either alone (as in blowing the nose or spitting), or mixed with the pulmonary transpiration, or with the excremental matter, &c.

MULATTO is commonly used to signify the offspring of a black and a white. The mulatto is of a yellow colour, with curled or woolly hair, and resembles the European more than an African. The descendants of Europeans and Indians are called *mestizos*. In Spain, the term *mulatto* is often applied to those persons in whom the Moorish blood has been mingled with the Spanish.

MULBERRY; a genus of plants allied to the nettle, and belonging to the natural family *urticeæ*. It is a native of China, and the Chinese claim the art of rearing silk-worms, and manufacturing stuffs, from a very remote period. From China, this art was introduced into India and Persia, and was practised there for many ages before it reached Europe. The Greeks became acquainted with silk subsequent to the time of Alexander; and it was not till the end of the Republic that the Romans for the first time saw this precious article. For many ages, silk bore an enormous price at Rome; but, about the middle of the sixth century, during the reign of Justinian, two monks arrived at Constantinople from India, bringing with them the white mulberry and the eggs of the silk-worm. From Constantinople, the white mulberry was introduced into Greece, and about the year 1130 into Sicily and Italy.

The first mulberry that was planted in France was living in 1802, and there still remain some stocks that are apparently of nearly the same age. It is now cultivated and naturalized throughout the south

of Europe, and in some of the central parts of that continent. In southern climates, the leaves appear to contain a less proportion of water, and more of that substance which causes the worms to produce silk in greater abundance and of a finer quality. In Greece, Asia Minor, and Persia, it is usual to give to the worms the branches, with the leaves attached to them; but in Spain, Italy, and France, the leaves are carefully stripped from the trees, taking care to despoil each tree entirely, otherwise the sap will be unequally attracted. The varieties of this tree are very numerous. The most approved mode of cultivation is from seed, and in the south of France no other mode is adopted.

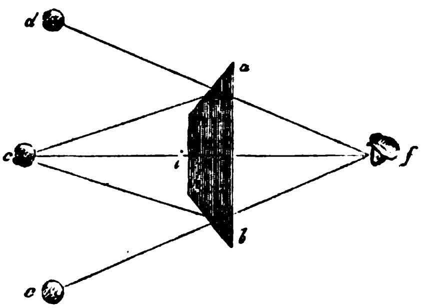
The *paper mulberry* is of a moderate size, bearing leaves which are either simple or divided into lobes more or less deep, rough above and hairy beneath. It was originally from India and Japan, but is now very commonly cultivated in Europe, and succeeds even in the more northern parts. For a long time the female plant was unknown in Europe, and at the present time it is rare in this country. The islanders of the Pacific make a kind of clothing from the bark of this tree in the following manner:—Twigs of about an inch in diameter are cut and deprived of their bark, which is divided into strips, and left to macerate for some time in running water. After the epidermis has been scraped off, and while yet moist, the strips are laid out upon a plank in such a manner that they touch at the edges, and two or three layers of the same are then placed upon them, taking care to preserve an equal thickness throughout. At the end of twenty-four hours the whole mass is adherent, when it is removed to a large, flat, and perfectly smooth table, and is beaten with little wooden clubs, till it has attained the requisite thinness. This kind of cloth is easily torn, and requires to be washed and beaten many times before it acquires its full suppleness and whiteness. The natives dye it red and yellow, and also make a similar cloth from the bread-fruit tree, but that from the mulberry is preferred.

The paper which is used in Japan and many other countries in the East Indies is made from this plant. For this purpose the annual shoots are cut after the fall of the leaves, tied in bundles, and boiled in water mixed with ashes; after which the bark is stripped off by longitudinal incisions, and deprived of the brown epidermis. The bark of the more tender shoots is separated from the rest, as it furnishes a very white paper for writing, while that produced by the remainder is coarse and gray, and serves for wrapping or similar purposes. The writing-paper is not suitable for quills, and these nations employ hair pencils, or the feathers of birds. For painting they make use of wooden blocks; and this, as well as the writing, can be executed only on one side. Silk-worms will eat the leaves of this tree indiscriminately, even when mixed with those of the white mulberry.

MULE, in *manufactures;* a machine, invented by Crompton in 1779, for producing finer yarn than was spun by the machines previously in use, and which has now nearly superseded the jenny. For producing threads of the finest kind a process is necessary which is called *stretching*, and which is analogous to that performed with carded cotton upon a common spinning-wheel. In this operation portions of yarn several yards long are forcibly stretched in the direction of their length, with a view to elongate and reduce those places in the yarn which have a greater diameter and are less twisted than the other parts, so that the size and twist of the thread may become uniform throughout. To effect the process of stretching, the spindles are mounted upon a carriage, which is moved backwards and forwards across the floor, receding when the threads are to be stretched, and returning when they are to be wound up. The yarn produced by *mule-spinning* is more perfect than any other, and is employed in the fabrication of the finest articles. The sewing-thread spun by mules is a combination of two, four, or six constituent threads. Threads have been produced of such fineness that a pound of cotton has been calculated to reach 167 miles. (See SPINNING.)

MULTIPLE, in *arithmetic*, is a number which contains another number a certain number of times. Thus eighteen is a multiple of six, or of three, or of nine, &c. A *Common multiple* of two or more numbers is that which contains those numbers a certain number of times. Thus thirty-six is a common multiple of four and nine, being equal to nine times the former, and four times the latter. To find the *least common multiple* of several numbers, reduce them all to their prime factors; then the product of the greatest powers of those prime factors is the least common multiple required.

MULTIPLYING GLASS, in *optics*, a plano-convex lens of which the rounded surface is ground into a series of small planes, and, as each plane gives a distinct pencil of rays, there will be as many images as there are plane surfaces in the glass.



Thus in the above figure *a b* represents the plane side of the glass, and *i c* a ray of light passing to the eye at *f*. Objects will appear at *d* and *e* exactly similar to that at *c*, in consequence of the rays of light impinging on the side planes, which by a new series of refractions give a distinct image to each plane. Images are not formed at the angles *g* and *h*.

MUMMIES; the dead bodies of the Egyptians, which were preserved by embalming. Owing either to the religious opinions of the Egyptians or to the nature of the country, which rendered interment inconvenient, or the want of fuel, which rendered burning difficult, they embalmed all their dead, and deposited them in subterraneous chambers, or in grottoes excavated in the mountains. An immense number of them have been found in the plain of Saccara, near Memphis; hence called the *plain of the mummies*, consisting not only of human bodies, but of various animals, or heads of animals, bulls, apes, ibises, crocodiles, fish, &c. Numerous caves or grottoes, with contents of the same kind, are

found in the two mountainous ridges which run nearly parallel with the Nile from Cairo to Syene. Some of the most remarkable of these tombs are those in the vicinity of ancient Thebes in the Lybian mountains, many of which were examined by Belzoni, and those near Eleithias (described by Hamilton), further up the river, which, though less splendid than the Theban sepulchres, contain more illustrations of the private life of the Egyptians. The sepulchral chambers are almost entirely covered with fresco paintings and bass-reliefs, and frequently contain statues, vases, &c. Some of them (the royal sepulchres) consist of suites of spacious halls and long galleries of magnificent workmanship. Those of private individuals vary according to the wealth of the deceased, but are often very richly ornamented. Many of these tombs have been ransacked by Arabs for the purpose of plunder, and great numbers of the mummies destroyed for the rosin or asphaltum they contain, which is sold to advantage in Cairo. The tombs and mummies are, many of them, two or three thousand years old, and are in part indebted for their preservation to the dryness of the soil and the mildness of the climate. The processes for the preservation of the body were very various. Those of the poorer classes were merely dried by salt or natron, wrapt up in coarse cloths, and deposited in the catacombs. The bodies of the rich underwent the most complicated operations, and were elaborately adorned with all kinds of ornaments.

Embalmers of different ranks and duties extracted the brain through the nostrils, and the entrails through an incision in the side; the body was then shaved, washed, and salted, and after a certain period the process of *embalming*, properly speaking, began. The whole body was then steeped in balsam and wrapped up in linen bandages; each finger and toe was separately enveloped, or sometimes sheathed in a gold case, and the nails were often gilded. The bandages were then folded round each of the limbs, and finally round the whole body, to the number of fifteen or twenty thicknesses. The head was the object of particular attention: it was sometimes enveloped in several folds of fine muslin, the first of which was glued to the skin, and the others to the first; the whole was then coated with a fine plaster. A collar of cylindrical glass beads of different colours was attached to the mask which covered the head, and with it was connected a tunic of the same material. The beads, both in the collar and tunic, were so arranged as to form images of divinities, of the scarabæus, the winged globe, &c. Instead of this the mummy was sometimes placed in a sort of sheath, made of paper or linen, and coated with a layer of plaster, on which were paintings and gilding. These paintings represented subjects relating to the duties of the soul, and its presentation to the different divinities; and a perpendicular hieroglyphical inscription in the centre gave the name of the deceased, and of his relations, his titles, &c. The whole was then placed in the coffin.

Those mummies which have been examined present very different appearances. One class has an opening in the left side, under the armpit, and in another the body is whole. Some of those which have been opened have been dried by vegetable and balsamic substances, others by salt. In the former case aromatic gums or asphaltum were used (the gums, when thrown into the fire, give out an aromatic odour); in these the teeth and hair are generally preserved; but, if exposed to the air, they are soon affected. Those prepared with asphaltum are of a reddish colour, and are in good preservation. Those dried with saline substances are of a black, hard, smooth appearance. On exposure to the air they attract moisture, and become covered with a saline substance. Those mummies which have no opening are also partly preserved by saline substances, and partly by asphaltum. In the latter, not only the cavities of the body are filled with it, but the flesh, bones, and every part seem to be penetrated by it: it was probably injected in a hot state. These are the most commonly met with. They are hard, black, and without any disagreeable smell. The whole mummies prepared with salt alone are white and smooth, and resemble parchment.

The coffin is usually of sycamore, cedar, or pasteboard; the case is entire, and covered within and without by paintings representing funeral scenes, and a great variety of other subjects: the name of the deceased is also repeated on them in hieroglyphic characters. The cover, which is also entire, is ornamented in the same manner, and contains too the resemblance of the deceased in relief, painted, and often gilded. The breast is covered with a large collar; a perpendicular inscription occupies the centre, and funeral scenes the sides. The coffin is often enclosed in a second, and even third case, each of which is also ornamented with similar representations.

Human bodies preserved in other ways, either by accident or by some artificial preparations, are also called mummies. The Guanches, or aboriginal inhabitants of the Canaries, preserved the bodies of their deceased friends, which have been found in great numbers in the catacombs in Palma, Ferro, Teneriffe, &c. The natives called them *xaxos*. They are dry, light, of a yellow colour and strong odour, and often injured by worms; they are enveloped in goat skins and enclosed in cases. They are supposed to have been dried in the air, after having had the entrails removed; and they were also covered with a sort of aromatic varnish. Humboldt found mummies prepared in a similar manner in Mexico. The Peruvians also had the art of preserving the bodies of their incas.

The burial-place of the Capuchin monastery at Palermo, in Sicily, is a large subterranean vault divided into several wide and lofty galleries, in the walls of which are niches containing several hundred human bodies, kept in an upright position by being fastened to the wall behind, and clothed in their usual dress. The monks have a peculiar manner of preserving bodies, which they keep secret. Natural mummies are frequently found preserved by the dryness of the air. In a vault of the cathedral at Bremen, called the *lead-cellar* (because it was formerly employed for melting lead for aqueducts and organ pipes), are bodies in good preservation. In the monastery of St. Bernard, on mount St. Bernard, the bodies of travellers who have been buried in the snow are deposited in a chapel, in which there are open windows protected by grates. They are placed in a sitting position, leaning each on another's breast. The cold prevents their putrefaction, and gives them time to dry. The Gaulish mummies, in the cabinet of comparative anatomy, in the Jardin

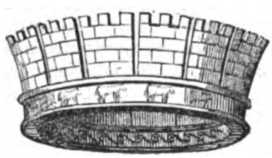
du Roi, were found in Auvergne in the last century. They bear no marks of any balsamic preparation, but are enveloped in linen, and appear to have been interred with great care. It is uncertain whether their preservation was owing to the nature of the soil or to a peculiar and now unknown process of embalming.

Mummies were formerly used in medicine, under the name of *mumia vera*, on account of the balsam they contained; but they have long ceased to be so employed.

MUMPS; the common name of the disease called, in scientific language, *cynanche parotidea*. It comes on with the usual febrile symptoms, which are soon attended with a swelling of the jaws and neck, sometimes on one side only, but commonly on both. The causes of it are not known with certainty. Children are more subject to it than adults. It seems sometimes to be the effect of cold. It is often epidemic, and, according to Cullen, is contagious. In general it runs its course without dangerous symptoms, and hardly requires any remedies; exposure to the cold should be avoided. The mean duration is from ten days to a fortnight.

MURAL ARCH; a wall, or arched wall, placed exactly in the plane of the meridian, for fixing a large quadrant, sextant, or other instrument, to observe the meridian, altitude, &c., of the heavenly bodies.

MURAL CROWN, in *heraldry*; an insignia of distinguished honour. The mural crown, of which a representation is given in the accompanying engraving, was originally given by the Roman senate as a reward to the soldier who first ascended the battlements of an enemy's wall. It was generally formed of gold; and, if the soldier placed the Roman standard on the wall, its value was considerably increased. By *murialle* is meant an ordinary that is walled.



MURIATES, in *chemistry*; a genus of salts, formed from the muriatic acid with certain bases.

MURIATIC ACID. The name of this acid is derived from *muria*, the Latin name of sea-salt, from which it is extracted. It is also called, in commerce, the *marine acid*, and the *spirit of salt*. Sometimes it is denominated the *hydrochloric acid*, in allusion to its composition. It is said to have been known as early as the time of Basil Valentine, though, as a gas, it was unknown till 1772, when it was obtained by Priestley, by heating the liquid acid, and receiving it in glass vessels filled with mercury. It is now procured in the gaseous form from the decomposition of common salt by sulphuric acid, and may be collected without the use of a mercurial cistern, simply by delivering it from the gas-bottle through a narrow tube, at the bottom of a phial or jar: the gas, being of a specific gravity of 1.259, displaces the air, and completely occupies the vessel. If an inflamed taper be immersed in it, it is immediately extinguished. It is destructive of animal life; but the irritation produced by it on the epiglottis scarcely permits its descent into the lungs. It is merely changed in bulk by alterations of temperature, but experiences no change of state. It is absorbed with great rapidity by water. A bottle full of the gas, if opened in water, is almost instantaneously filled.

Water absorbs about 500 volumes of this gas; and the solution, when cold, has the density of 1.1958. The common process for obtaining liquid muriatic acid is the following: common salt, sulphuric acid, and water, equal weights, the acid being mingled with one-third of water, and when cold poured on the salt; the gas evolved is conducted through reservoirs of water, and subjected to pressure in contact with it. The specific gravity of the acid thus obtained is 1. 17. It is generally slightly tinged with yellow, from the presence of muriate of iron derived from the vessels used in the process. It combines, like the other powerful acids, with the alkalies, earths, and metallic oxides, forming a very peculiar class of salts. The following table contains the quantity of real acid in 100 parts of liquid muriatic acid, at the temperature of 60°, according to *Dalton*.

Atoms.			Acid per cent. by weight.	Acid per cent. by measure.	Specific Gravity.	Boiling Point. 60°.
Acid.		Water.				
1	+	1	73.3			
1	+	2	57.9			
1	+	3	47.8	71.7 ?	1.500 ?	
1	+	4	40.7			
1	+	5	35.5			
1	+	6	31.4			
1	+	7	28.2			
1	+	8	25.6	30.5	1.199	120
1	+	9	23.4	27.5	1.181	145
1	+	10	21.6	25.2	1.166	170
1	+	11	20.0	23.1	1.154	190
1	+	12	18.7	21.4	1.144	212
1	+	13	17.5	19.9	1.136	217
1	+	14	16.4	18.5	1.127	222
1	+	15	15.5	17.4	1.121	228
1	+	20	12.1	13.2	1.094	232
1	+	25	9.91	10.65	1.075	228
1	+	30	8.40	8.93	1.064	225
1	+	40	6.49	6.78	1.047	222
1	+	50	5.21	5.39	1.035	219
1	+	100	2.65	2.70	1.018	216
1	+	200	1.36	1.37	1.009	214

We add also a table of the quantity of muriatic acid gas in solutions of different specific gravities, according to *Sir H. Davy*.

At temperature 45° Fahren. Barometer 30.			At temperature 45° Fahren. Barometer 30.		
100 parts of solution of muriatic acid gas in water, of spec. gravity.		Of muriatic acid gas, parts.	100 parts of solution of muriatic acid gas in water, of spec. gravity.		Of muriatic acid gas, parts.
1.21	Contain	42.43	1.10	Contain	20.20
1.20 •		40.80	1.09		18.18
1.19		38.38	1.08		16.16
1.18		36.36	1.07		14.14
1.17		34.34	1.06		12.12
1.16		32.32	1.05		10.10
1.15		30.30	1.04		8.08
1.14		28.28	1.03		6.06
1.13		26.26	1.02		4.04
1.12		24.24	1.01		2.02
1.11 •		22.3			

Muriatic acid is a valuable article of the *materia medica*. It is particularly used in cases of dyspepsia that are attended with morbid secretions, in hepatic derangements, and in cutaneous diseases. It is also of considerable value as a disinfecting agent.

MURRAIN; a contagious disease among cattle, principally caused by a hot, dry season, or general putrefaction of the air, which begets an inflammation of the blood and a swelling in the throat, which soon prove mortal. The symptoms are a hanging down and swelling of the head, abundance of gum in the eyes, rattling in the throat, a short breath, palpita-

tion of the heart, staggering, a hot breath, and a shining tongue.

MUSCLE. In our article ANATOMY the reader will find a general account of the human structure, including a list of the bones forming the frame-work, which give to it form and stability; and it may now be advisable to examine the muscles, or cords, by which the motions are performed. It would, however, be too severe a tax on the reader, in a work not expressly intended for the education of medical students, to enter into a verbal list of many pages in extent merely to enumerate the muscles as they occur in the human body; we shall therefore confine ourselves to their general structure, uses, and chemical character. The parts that are usually included under this name consist of distinct portions of flesh susceptible of contraction and relaxation, the motions of which, in a natural and healthy state, are subject to the will; and for this reason they are called *voluntary* muscles. Besides these, there are other parts of the body that owe their power of contraction to their muscular fibres; thus the heart is a muscular texture, forming what is called a *hollow* muscle; and the stomach, intestines, &c., are enabled to act upon their contents, merely because they are provided with muscular fibres: these are called *involuntary* muscles, because their motions are not dependent on the will. The muscles of respiration being, in some measure, influenced by the will, are said to have a *mixed* motion. The names by which the voluntary muscles are distinguished are founded on their size, figure, situation, use, or the arrangement of their fibres, or their origin and insertion; but, besides these particular distinctions, there are certain general ones that require to be noticed. Thus, if the fibres of a muscle are placed parallel to each other, in a straight direction, they form what is called a *rectilinear* muscle; if the fibres cross and intersect each other, they constitute a *compound* muscle; when the fibres are disposed in the form of rays, a *radiated* muscle; when they are placed obliquely with respect to the tendon, like the plume of a pen, a *penniform* muscle.

Muscles that act in opposition to each other are called *antagonists;* thus every extensor has a flexor for its antagonist, and *vice versâ*. The muscles being attached to the bones, the latter may be considered as levers, that are moved in different directions by the contraction of those organs. That end of the muscle which adheres to the most fixed part is usually called the *origin*, and that which adheres to the more movable part the *insertion* of the muscle.

In almost every muscle, two kinds of fibres are distinguished; the one soft, of a red colour, sensible, and irritable, called *fleshy* fibres; the other of a firmer texture, of a white glistening colour, insensible, without irritability or the power of contracting, and named *tendinous* fibres. They are occasionally intermixed, but the fleshy fibres generally prevail in the *belly* or middle part of the muscle, and the tendinous ones in the extremities. If these tendinous fibres are formed into a round slender cord, they form what is called the *tendon* of the muscle; on the other hand, if they are spread into a broad flat surface, it is termed an *aponeurosis*. The fibres that compose the body of a muscle are disposed in *fasciculi*, or bundles, which are easily distinguishable by the naked eye; but these fasciculi are divisible into smaller ones; and these, again, are probably subdivisible *ad infinitum*. The most minute fibre we are able to trace seems to be somewhat plaited; these plaits, disappearing when the fibre is put upon the stretch, seem evidently to be the effect of contraction, and have probably induced some writers to assert that the muscular fibre is twisted or spiral.

A fibre is essentially composed of *fibrin* and *ozmazome*, receives a great deal of blood, and, at least, one nervous filament. The chemical analysis will be noticed hereafter, and it may be enough to state that the muscle is found to consist chiefly of fibrin, with albumen, gelatin, extractive matter, phosphates of soda and of ammonia, phosphate and carbonate of lime, and sulphate of potassa. Each muscle is surrounded by a thin and delicate covering of cellular membrane, which dipping down into its substance encloses the most minute fibres we are able to trace, connecting them to each other, lubricating them by means of the fat which its cells contain, in more or less quantity in different subjects, and serving as a support to the blood-vessels, lymphatics, and nerves, which are distributed through the muscles. The muscles owe the red colour which so particularly distinguishes their belly part to an infinite number of arteries, which are every where dispersed through the whole of their reticular substance; for their fibres, after having been macerated in water, are (like all other parts of the body divested of their blood) found to be of a white colour. The veins, for the most part, accompany the arteries, but are larger and more numerous. The lymphatics are numerous, as might be expected from the great proportion of reticular substance which is every where found investing the muscular fibres. The nerves are distributed in such abundance to every muscle that the muscles of the thumb alone receive a greater proportion of nervous influence than the largest viscera.

Muscular motions are of three kinds, namely, voluntary, involuntary, and mixed. The *voluntary* motions of muscles proceed from an exertion of the will: thus the mind directs the arm to be raised or depressed, the knee to be bent, the tongue to move, &c. The *involuntary* motions of muscles are performed by organs, without any attention of the mind, as the contraction and dilatation of the heart, arteries, veins, absorbents, stomach, intestines, &c. The *mixed* motions are those which are in part under the control of the will, but which ordinarily act without our being conscious of their acting; and are perceived in the muscles of respiration, the intercostals, the abdominal muscles, and the diaphragm.

When a muscle acts, it becomes shorter and thicker; both its origin and insertion are drawn towards its middle. The sphincter muscles are always in action; and so likewise are antagonist muscles, even when they seem at rest. When two antagonist muscles move with equal force, the part which they are designed to move remains at rest; but if one of the antagonist muscles remains at rest, while the other acts, the part is moved towards the centre of motion. When a muscle is divided, it contracts. If a muscle be stretched to a certain extent, it contracts, and endeavours to acquire its former dimensions as soon as the stretching cause is removed. When a muscle is wounded, or otherwise irritated, it contracts independently of the will; this power is called *irritability*, and it is a property peculiar to and inherent in the muscles. When a muscle is stimulated, either through the medium of the will or any foreign body, it contracts, and its contraction is greater or less in pro-

portion as the stimulus applied is greater or less. The contraction of muscles is different, according to the purpose to be served by it: thus the heart contracts with a jerk; the urinary bladder slowly and uniformly. The intensity of muscular contraction, that is, the degree of power with which the fibres draw themselves together, is regulated by the action of the brain: it is generally regulated by the will, according to certain limits, which are different in different individuals. A particular organization of the muscles is favourable to the intensity of their contraction: this organization is a considerable volume of fibres, strong, of a deep red, and striated transversely. The cerebral influence, and the disposition of the muscular tissue, are the two elements of the intensity of muscular contraction. A very great cerebral energy is rarely found united, in the same individual, with that disposition of the muscular fibres which is necessary to produce intense contractions: these elements are almost always in an inverse ratio. When they are united, they produce astonishing effects. Perhaps this union existed in the *athletæ* of antiquity; in our times, it is observed in certain mountebanks.

'The muscular power may be carried to a wonderful degree by the action of the brain alone: we know the strength of an enraged person, of maniacs, and of persons in convulsions. The will governs the duration of the contraction: it cannot be extended beyond a certain time, however it may vary in different individuals. A feeling of weariness takes place, not very great at first, but which goes on increasing until the muscle refuses contraction. To prevent this inconvenience, the motions of the body are so calculated that the muscles act in succession, the duration of each being but short: our not being able to rest long in the same position is thus explained, as an attitude which causes the contraction of a small number of muscles can be preserved but for a very short time. The feeling of fatigue occasioned by muscular contraction soon goes off, and, in a short time, the muscles recover the power of contracting.

The quickness of the contractions are, to a certain degree, subject to cerebral influence: we have a proof of this in our ordinary motions; but beyond this degree it depends evidently on habit. In respect of the rapidity of motion, there is an immense difference between that of a man who touches a piano for the first time, and that which the same man produces after several years' practice. There is, besides, a very great difference in persons, with regard to the quickness of contraction, either in ordinary motions or in those which depend on habit. As to the extent of the contractions, it is directed by the will; but it must necessarily depend on the length of the fibres, long fibres having a greater extent of contraction than those that are short. The will has generally a great influence on the contraction of muscles; it is not, however, indispensable: in many circumstances motions take place, not only without the participation of the will, but even contrary to it: we find very striking examples of this in the effects of habit, of the passions, and of diseases.

In *Plate* II. Anatomy, *fig.* 1, we give a front view of the outermost muscles viewed anteriorly. *a.* Platysma myoides. *b.* Deltoides. *c.* Biceps brachii. *d.* Pronator radii teres. *e.* Supinator radii longus. *f.* Flexor carpi radialis. *g.* Palmaris longus. *h.* Flexor carpi ulnaris. *i.* Pectoralis major. *j.* Obliquus descendens externus. *k.* Linea Semilunaris. *l.* Linea alba. *m.* Poupart's ligament. *n.* Sartorius. *o.* Tensor vaginæ femoris. *p.* Gracilis. *q.* Iliacus internus. *r.* Pectinalis. *s.* Triceps adductor femoris. *t.* Psoas magnus. *u.* Vastus externus. *v.* Vastus internus. *w.* Rectus.

Fig. 2. is a back view of the superficial muscles. *a.* Trapezius. *b.* Latissimus dorsi. *c.* Deltoides. *d.* Triceps extensor cubiti. *e.* Gluteus maximus. *f.* Biceps flexor cruris. *g.* Semitendinosus. *h.* Semimembranosus. *i.* Gastrocnemius externus.

The chemical character of muscular fibre must next be examined. Their basis appears to be fibrin not much changed, with which are intermingled small portions of albumen, gelatin, an extractive and saline matter, these being derived in part from the blood diffused by the medium of the blood-vessels. To this, too, the colour is owing, as when washed with water the muscular substance remains white. The water employed in this operation holds dissolved the other principles. When heated, the albumen is separated by coagulation in flakes; if these are removed, and the liquor evaporated, it becomes gelatinous, a little fatty matter separating and collecting on the surface; and by this experiment the albumen and gelatin are detected. Besides these, a portion of a peculiar extractive matter is obtained by evaporating the jelly to dryness, and treating it with alcohol, the alcohol dissolving the matter, and yielding it by evaporation, in a solid form. It is of a brownish colour, has a pungent odour, and a taste somewhat aromatic: according to Berzelius, it consists of lactic acid, partly combined with alkaline bases and with animal matter. Lastly, the saline matter is procured by pouring boiling water on the muscular fibre, previously washed; it consists of phosphates of soda and ammonia, and phosphate and carbonate of lime. The proportions of these differ at different periods of life, being more abundant in the coarse and rigid muscular fibre of adult animals than in the more delicate fibre of those who are young. In the latter the proportion of gelatin is larger than in the former. When these have been extracted, the fibre remains, which has all the qualities of the fibrin of the blood.

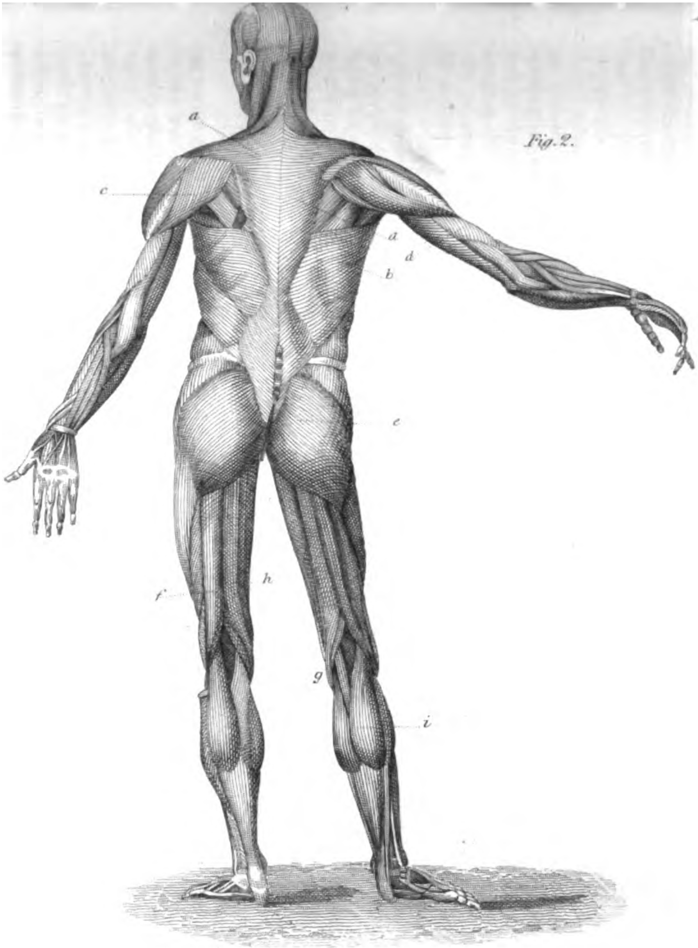
When the flesh, without preparation, is boiled in water, the gelatin and albumen are more completely dissolved, and the fibrin is diffused in threads in the boiling liquor. The albumen coagulates, the gelatin is detected by the precipitate formed with tannin, or, if the liquor be sufficiently evaporated, it renders it gelatinous.

When the muscular substance is exposed to the air, it soon becomes tainted, and at length putrid, a change principally arising from the presence of gelatin, which is peculiarly liable to putrefaction when humid; and accordingly, if it has been removed by washing, the flesh remains much longer sound. It may be proper to add that, for experimental purposes, when the blood is of necessity retained, the chloride of lime may be advantageously employed.

Muscular fibre, decomposed by heat, affords the usual products of animal matter. Its residual charcoal gives, by incineration, carbonate and phosphate of lime.

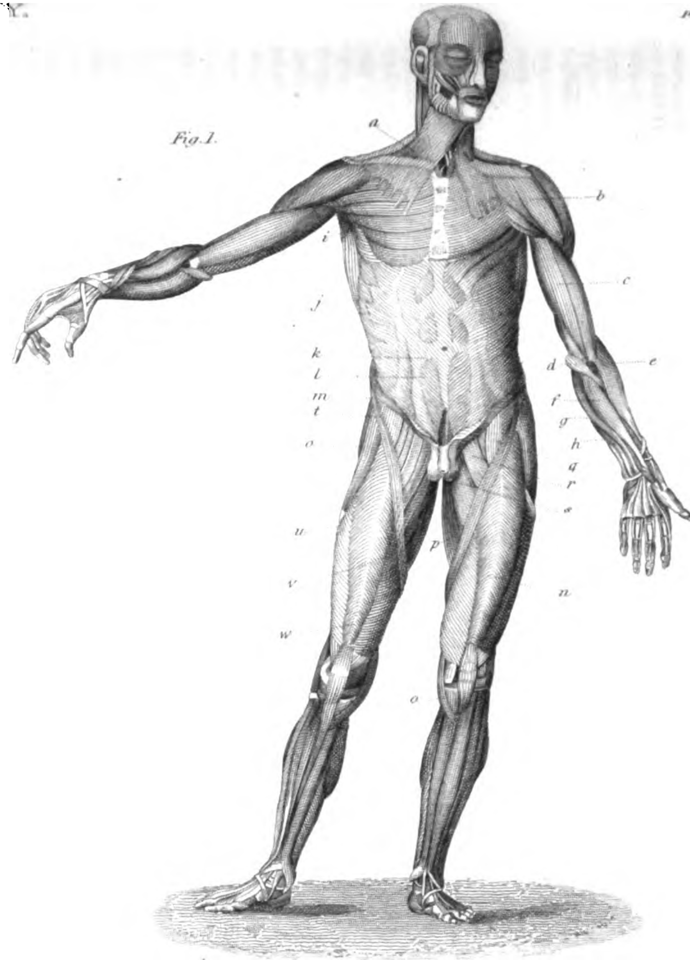
The acids decompose the muscular fibre. Nitric acid disengages nitrogen gas, with a portion of carbonic acid gas, and the principal product is an unctuous substance of a yellow colour, rancid smell, bitter taste, and sensibly acid. The unctuous matter

Fig. 2.



BACK VIEW

Fig. 1.



FRONT VIEW

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may be separated by the action of alcohol from the acid.

MUSIC. Nature seems to have established an intimate connection between the emotions of the mind and the sense of hearing. Of the two nobler senses, sight and hearing, the first seems to belong more particularly to the understanding: we owe to the eye, and to abstractions from the images which it presents, most of our general notions and ideas; while the ear appears to be more intimately connected with the feelings. Feeling expresses itself most readily in tones. Fear, joy, desire, anger, have each a peculiar tone, understood by all human beings. Man soon perceives this, and often prolongs these tones, in order to continue or heighten a certain feeling or excitement; hence the repetition of the war-cry, in the combats of rude tribes, or of the tones of mirth at their festivities. The love of excitement, moreover, soon leads to the production of these tones, even on occasions when the feeling from which they first originated does not exist: thus we find the natural tones of joy repeated, in order to produce that of which they were originally the effect,—a pleasant feeling, a contented state of the soul. This, it is true, is not yet music or song, but it is the first germ of it.

Another element of music, springing from a feeling deeply planted in the human heart, and perceptible in children and savages as well as in the most refined and accomplished, soon associates itself with tones: we mean rhythm. Whatever may be its origin,—whether it was first used to relieve the fatigue of a march, or to give connection to a series of tones, or to enable numbers to join in the utterance of the same tones, or whether it is to be referred mainly to the spirit of classification and love of order which are so universally operative,—certain it is that the love of rhythm is one of the most general principles of the human soul: it pervades all tribes, all ages, all classes. It alleviates labour, and cheers the heart.

A simple division of tones soon gave place to a more artificial one, it being readily perceived that a man might utter two short tones, and make two short steps, in the same time as one long tone or one long step. Man does this long before he reflects on it: witness the regular strokes of the smith's hammer or the thresher's flail, and the dances of the rudest nations: thus we have the two essential elements of song—tones and rhythm. As precise divisions in sciences or arts, or any of the departments of human action, are effected but slowly, and kindred branches are at first usually mingled, it is highly probable that dancing and music—two arts founded on measured time—were at first intimately connected, as we find still to be the case among most, perhaps all, tribes in a state of infancy. By degrees, the song was separated from the dance, and instruments which originally served only to accompany the song became also the object of a separate art. Tones by themselves, apart from dance or words, were cultivated; the laws according to which they must be connected, so as best to express the language of feeling, were more and more investigated, and the application of these laws further and further extended, until music was developed to that degree of perfection which we admire in the works of the greatest masters.

Every musical production, to deserve the name, must be expressive of feelings, and through them of ideas; but, though music exists wherever the human species is found, it does not follow that every good piece of music must please all men alike, or be understood by all alike, because music is an art requiring cultivation of the mind and heart, to appreciate it fully; still, however, music, even of the most elevated kind, retains so much of its character of universality that the productions of the greatest masters delight much more generally than the best performances in other arts. Witness, for instance, certain tunes of Mozart, or other great composers, which are repeated on all occasions, so that they not unfrequently become tedious from this cause. The Hunter's Chorus in the Freischütz may be heard throughout Europe and America. The reason is, that music addresses the feelings, and feeling is alike all over the world. In this point of universality, music and mathematics (incongruous as the association may seem) agree, the relations of numbers and magnitudes, with which mathematics have to deal, being every where the same, and the simple feelings of the heart, which music addresses, being common to every region. Insensibility to music may generally be referred to a defective organization in the sense of hearing; but the whole conformation of some men is probably much better fitted than that of others to enable them to receive pleasure from it. In this respect, too, music and mathematics seem to have a resemblance, that great excellence in either appears to require a marked peculiarity in the nature of the individual. Music is based on melody, rhythm, and harmony.

The effects of music are sometimes said to be merely sensual. It is addressed to the ear, indeed; but all the influences which we receive from without are conveyed through the medium of the senses, and the tones of music often speak a language to the soul richer in meaning than any words. It will hardly be pretended that feelings which cannot be expressed in words are necessarily of a lower character than those which may be so expressed. The most elevated feelings are beyond the power of even metaphorical language. Nothing is merely sensual which makes a lasting spiritual impression upon the soul; and he who denies to music such a power has not heard its sublimest strains, or has not the capacity to appreciate them.

In music, we have to distinguish the invention (called *composition*) and the *execution*. As to the latter, it may be vocal or instrumental; and, as to the purposes for which music is intended, we have *church* or *sacred* music, *theatrical* music, *concert*, *dancing*, &c.

Wherever we find music, even in its rudest beginnings, we find also instruments; so that, as far as respects the known history of this art, we must consider the developement of vocal and instrumental music as coeval. Perhaps the first instrument invented was the pipe of the shepherd, who, in his life of leisure, heard the wind whistle among the reeds. It seems probable that shepherds first cultivated music as an art, though warriors may have used the exciting war-cry and war-song before. Instruments, as before observed, served in the beginning only as an accompaniment.

According to the Mosaic records, Jubal, the son of Lamech, played on musical instruments, even before the deluge. At a later period, we find among the Hebrews, as is the case in the early periods of all nations, the character of poet and singer united in the same individual, and with them we also find the alternating chorus. The musical instruments which accompanied these songs were harps, citherns, trumpets, and drums. One of the oldest songs, with in-

strumental accompaniments, of which we have any record, is that which Miriam sung, after the passage of the Red Sea. At the time of David and Solomon, music had reached its highest perfection among the Hebrews, and part of their religious service consisted in chanting solemn psalms, with instrumental accompaniments. As far as we can judge, from the information handed down to us, and even from the structure of Hebrew poetry itself (of which a certain parallelism, or repetition of the main idea in the different members of a sentence, was the chief characteristic) it had a very distinct rhythm, a varied melody, but a monotonous though strong accompaniment, as was the case with the music of most ancient nations. They had also proper musical signs, which were put over the musical text, and which served to guide the recitation. Their music, however, was employed not only in the celebration of religious service, in which, particularly since the time of David, a great number of singers, male and female, and instrumental performers, were employed, but also at profane festivals, such as large entertain ments. At this time, the different kinds of instruments were increased, among which the *kinnor* (triangular harp), and the cymbal, are mentioned particularly.

In the tomb of Osymandyas, near Thebes, musical instruments have been found, and it has been concluded that the Egyptians must have been acquainted with music 2000 years B.C. That the Hebrews received the art from them would not, however, be proved by that circumstance, though it may be, for various reasons, probable. We pass over the mythological accounts respecting the origin and perfection of the art of music among the Greeks. The traditions indicate that they received this art, or, at least, great improvements in the execution of it, from Lydia, where Amphion is said to have learned music, and Arcadia, where the shepherds practised on the pipe, flute, and cithern.

From the provinces of Asia Minor, the different modes of Greek music—the Phrygian, Dorian, Lydian, Æolian, and Ionian—are derived. Their song, as it would appear from what we can gather from the ancient authors, consisted in a musical recitation, accompanied by one or more instruments to support the rhythm. From the sixth century B.C., music seems to have been studied scientifically, and particularly the tones were measured. Lasus, of Hermione, in the Peloponnesus, who lived about 546 B.C., and was the teacher of Pindar, is said to have written something on the theory of music.

Pythagoras, who is said to have learned music from the Egyptian priests (which, however, is considered improbable) occupied himself with the mathematical relations of tones. The instrument which he invented for the mathematical determination of sounds was called the *Pythagorean canon*. He is also said to have added the eighth chord to the harp, to which several others were afterwards added. Damon is mentioned as one of the most distinguished teachers of music in the times of Pericles and Socrates. Plato asserted that his music could not be changed without changing the constitution of the state itself.

Plato and Aristotle considered music useful as a means of education. In their time, the scale was considerably increased; but, at the same time, complaints arose against the degeneracy of music and of the national manners through its influence. A similar complaint was made against Phrygius, who lived in the time of Socrates. Probably the cause of it was the application of music to the expression of the more tender feelings, as love, &c., while it had been previously used chiefly to awaken patriotic or religious feeling, as with the Lacedæmonians. The division into theoretical and practical music was probably known even then. Theoretical music comprised as well the arithmetical calculations respecting the proportions of sound and tones as the doctrine of harmony, which teaches the general rules of all the various concords. Composition and song depended upon this branch. The latter, and thus music in general, was divided, according to the proportions of the tones required in the different sorts of music, into the diatonic, enharmonic, and at a later period the chromatic. In regard to the tones which were the basis of these compositions, certain modes were adopted, denominated, as has been already stated, from the countries whence they chiefly came. Music was divided also, in respect of composition, into, 1. the art of composing the song, that is, the art of giving to poetry the proper song, or mode of recitation, because the recitation, or declamation, was also indicated by notes; 2. the art of giving a proper rhythm to the motion of the body or the voice; and, 3. into *poetics*, the technical part of poetry, connected intimately with music in those times: to this belonged *metrics*. As to execution, music was divided into instrumental music, vocal music, and pantomimic action in connection with music. At the time of Alexander the Great, Aristoxenus, a pupil of Xenophilus and Aristotle, distinguished himself. He wrote a great number of treatises on music, of which three are still extant, and extended the scale to eighteen chords, which were divided according to tetrachords and pentachords. His pupils (called the *Aristoxenians*) rejected the strict proportions of Pythagoras, and made use of the intervals of whole and half tones, guided merely by feeling. Aristoxenus also introduced the chromatic music, the invention of which belongs to this time, instead of the enharmonic.

Euclid (277 B.C.) is the first writer who treated the mathematical doctrine of sounds. With the decline of liberty, music also sunk, like the other arts. The Romans seem to have received the music which they used at sacrifices, together with the religious service, from the Etruscans, but the instrumental music, used on the stage and in war, from the Greeks. Stringed instruments are said to have been introduced into Rome as late as 186 B.C. In general, the Romans, so warlike in their disposition, most cultivated martial music. At an early period of their history, it was a great hindrance to the progress of the art that it was practised only by slaves.

With the Romans, *canere* and *carmen* signified the musical recitation, which was accompanied by instruments, and which seems to have stood in the same relation to rhetorical recitation as the poetic *rhythmus* to the *numerus* of prose; to which we must add, however, that orators had the intonation given by instruments at the beginning of their speech and during the same. The Romans made use of their capital letters as notes. On the stage, the song was accompanied with flutes. The instruments first preluded; then the actor began; and probably the instrumental accompaniment continued in simple concords, or made short pauses and supported or heightened the emphatic expression by recommencing.

The choruses seem to have been accompanied differently from the monologue and dialogue. This accompaniment consisted of flutes and other wind instruments, comprised with the Romans under the name of *tibiæ;* sometimes, also, of the lyre and cithern. The flutes were different, according to the comic or tragic poem which they had to accompany; hence there were *tibiæ dextræ* and *sinistræ*, the former particularly intended for the serious, the latter for the comic passages, and for comedies. Horace, in his *Epistola ad Pisones,* says that formerly only simple wind-instruments, with a few holes, had been used; no flutes which vied with the trumpets (*tubæ*). Rhythm and melody, he says, had become less strict. At later periods, still louder complaints were raised against the noise of the instruments, which obliged the actor to raise his voice extremely. In all this, the Greeks had preceded the Romans. Under the four emperors, particularly Nero, music was cultivated as an object of luxury. After his death, 500 singers and musicians are said to have been dismissed.

From the sixteenth and seventeenth centuries, there grew up at the courts of monarchs the free chamber style, and, from this, the theatrical style. The invention of the opera, in the sixteenth century, has chiefly contributed to the splendour and variety of modern vocal music, and the astonishing improvement in the mechanical structure of various instruments greatly advanced instrumental music, and at the same time harmony, in the latter half of the eighteenth century. The merit of the advancement of vocal music is claimed particularly by the Italians; the improvement of instrumental music by the Germans, French, and English.

The invention of the *lyric drama* of the moderns is considered by many persons to be of very distant date; that is to say, if by the lyric drama we are to understand every representation accompanied by music. And in fact, although these older representations differ widely from the lyric drama of our time, still the musical observer cannot fail to remark in the former the foundation and essential principles of the latter.

An *Orfeo* of Angelus Politianus was composed as early as the year 1475, and a musical tragedy is spoken of as having been performed at Rome in 1480. It is said that, in 1555, Alphonso della Viola set to music, for the court of France, "*Il Sacrifize,*" a pastoral drama by Agostino Beccari; and in 1574 an opera was performed at Venice for the reception of Henry III., when, on his return from Poland, he passed through that town, in order to take possession of the crown of France, to which he succeeded on the death of his brother Charles IX. These facts are so remote, and so very few vestiges of them remain, that it is impossible to deduce any thing positive as to the state of this branch of the musical art at that early period.

The real epoch to which the birth of dramatic music, properly so called, may be fixed, is that of the invention of the recitative or recited music, which gave to the lyric drama a peculiar language and construction. The following, it is said, was its origin.

Three Florentine gentlemen, J. Bardi, P. Strozzi, and J. Corsi, amateurs of the art, being little satisfied with the attempts made up to their time to bring dramatic poetry to perfection, conceived the idea of having a lyric drama written by their best lyric poet, and composed by the most eminent of their musicians. They consequently selected Ott. Rinuccini and Jacq. Peri, both of them Florentines: the former wrote a poem entitled *Daphne*, to which the latter applied a sort of recitation, in notes, having all the sounds of music, without its regular support and marked time. The work, thus arranged, was performed in 1597, at the house of Corsi, and obtained the utmost success; so much so as to determine Rinuccini to write two other works of the same kind, namely, *Euridice* and *Ariana*. In the same year in which *Ariana* was performed at Florence, an oratorio, with the same description of recitative, composed by Emilio del Cavalière, and entitled *Di Amina e di Corpo,* was performed at Rome. This work, together with that of Peri, was published in 1608; and in their prefaces the two authors claim the honour of the invention of recitative, which they both maintain to be the revival of the chanting declamation of the Greeks. Each of them, in support of his claim, cites different works written previously to the time of which we have just been speaking; and Emilio, especially, mentions a drama of his own, entitled *La Disperatione del Satiro,* composed and performed in private since the year 1590, and another represented in 1595. If we may credit J. B. Doni, the invention or revival of recitative belonged neither to the one nor the other, but to Vincent Galileo, father of the celebrated Galileo the astronomer, who feeling, as well as Bardi and the other amateurs of Florence, the defects in the music of that age, and inspired with the ardour of research, occupied himself in recovering the musical declamation of the Greeks, and, having studied the recitative, applied it to the episode of the *Count Ugolino* of Dante. He composed also, in the same style, *The Lamentations of Jeremiah,* and sang them himself, with a viol accompaniment, before a numerous assembly. Julius Caccini, of Rome, a young singer, who frequented, with many other musicians, the house of Bardi, was enthusiastic in his admiration of this new style, and himself composed several pieces, with recitative of a very improved description. J. Peri became his rival in improvements, and both, according to Doni, cooperated in setting to music the *Daphne* of Rinuccini. Peri afterwards composed *Euridice,* and Caccini *Cephalus.* These pieces were followed by *Ariana,* which was put into recitative by Cl. Monteverde. Of all the above-named works, the *Euridice* of Peri was most successful when performed in public. This representation took place in 1600, at Florence, on the occasion of the marriage of Henry IV. of France with Mary de Medicis. In the preface to the poem, which was printed the same year, Rinuccini states that the music composed by Peri to his *Daphne* had made him cease to fear that he should never witness the revival of the musical declamation of the Greeks. In fact, nearly the whole of this work is in recitative; and it is difficult to discover any difference from the rest of the music in those passages at the head of which is placed the word *aria.* The same observation applies to all the works composed up to the middle of the same century. It is only in the opera of *Jason,* written by Cicognini, and set to music in 1649 by Cavelli, that we begin to perceive airs having a melody differing from that of the recitative; yet still these airs are usually insipid, and generally (to give

some idea of them) a kind of minuet, written in the time of *two-three*, and varying repeatedly. A greater degree of progress is perceptible in the operas of Cesti, who, in his *Doria*, composed in 1663, began to introduce airs in which the talents of the singer might be displayed to advantage. But what is particularly remarkable at this epoch is, that the opera began to degenerate into a *spectacle* calculated to please the sight alone; insomuch that, in the works represented about the end of the seventeenth century, no mention whatever is made either of the poet, the composer, or the singers, but only of the machinist and the decorator. This, however, did not discourage an immense number of composers from devoting themselves to this style. Among these, there were many who had both practical knowledge and genius, to prove which it is sufficient to name Fr. Gasparini, Perti, Collonna, Lotti, and, above all, the celebrated Alessandro Scarlatti, to whom the invention of the *obligato* recitative is generally attributed. The principal characteristic of these celebrated composers of operas is however their science; and perhaps this was all they could do at a period such as that in which they wrote.

In the midst of this confusion, some few among them, and particularly Scarlatti, felt the necessity of making the melody conformable to the expression of the words; and some attempts made to this effect were very successful. This great improvement was, however, left to be completed by the composers of the eighteenth century; and it is to the illustrious pupils of Scarlatti, namely, to Leo, Vinci, Sarrow, Hasse, Porpora, Feo, Abos, and especially Pergolese, that this approach to perfection is attributable. They were well seconded by the poets of their time, and particularly by Apostolo Zeno, and his pupil Metastasio, who presented them with poems, written with purity and elegance, and full of interesting incident. Three generations may be considered to have followed this same system, profiting by the successive embellishments of melody and of the orchestra.

Didactic authors, such as Bernardi and Padre Martini, usually distinguish three styles of chamber music, namely, simple madrigals, accompanied madrigals, and cantatas. To these we may with propriety add a fourth, namely, fugitive pieces, containing an immense number of different sorts and varieties.

The madrigal is a species of composition much resembling the fugue (see FUGUE), but the style, being less dry than that of the latter, is susceptible of every kind of expression. It was so called from being usually set to a peculiar kind of short poem, known also by that name. There are two kinds of madrigals: namely, simple madrigals, or those executed by voices alone, and accompanied madrigals, or those in which the voices are supported by the organ or piano-forte.

Simple madrigals appear to have been invented at the beginning of the sixteenth century. During the whole of the succeeding century this style was very much cultivated, but since the early part of the eighteenth it has been completely abandoned, as much from the recognized difficulty of equalling the early composers in this kind of music as on account of the attention given exclusively to dramatic and instrumental music, which are, in some respects, completely the antipodes of this system.

Accompanied madrigals are, necessarily, a more modern invention; they can have existed only since the time when the custom was introduced of putting an instrumental bass, differing from the vocal one, below the voices. The most celebrated composers of this species of madrigal flourished between the middle of the seventeenth and beginning of the eighteenth centuries. These are Frescobaldi, Carissini, Lotti, Scarlatti, Clari, Marcello, and Durante; the last three of whom in particular have left some *chefs-d'œuvre* in this style of composition.

A cantata is a short poem which, considered in a literary sense, has no very determinate character, though it is usually the recital of a simple and interesting fact, interspersed with reflections, or the expression of some particular sentiment. It may be in all styles and all characters, sacred, profane, heroic, comic, and even ludicrous; representing the action or feeling of either a single or several persons; it even sometimes assumes the character of the oratorio; as, for instance, in the sacred poem of *The Passion*, *The Creation* of Haydn, and others. The cantata is supposed to have been invented about the commencement of the seventeenth century. Like the madrigal, this style of composition has been generally abandoned and neglected for nearly two generations; so much so that learned amateurs alone now deign to study the masterpieces left to us in this style.

Fugitive pieces consist, as we have before said, of an immense number of styles, and an amazing variety of subjects. Every nation has its peculiar style of music. Italy has the *canzonette*, the *villanelle*, the *flotole*, the *estrambotte*, &c.; Spain the *bolero*, &c.; France the *romance*, the *vaudeville*, &c.

We may now notice the introduction of the *gamut*, and the origin of counterpoint. With regard to the former, the invention of the *gamut* presupposes a certain degree of progress in the musical system, in the same manner that the alphabet conveys the preliminary idea of the existence of a language. We make this remark that the scale of music may not be confounded with the *system*, which might otherwise easily be the case. It was in the commencement of the eleventh century, in the year 1022, that the musical scale first took the form which it still retains. This reformation was chiefly owing to Guido, a Benedictine monk of the monastery of Pomposa, born about 990, at Arezzo, a little town of Tuscany, for which reason he is commonly called in France Guy d'Arezze. Between the death of Pope Gregory and the period of which we are now speaking, many attempts were made to improve musical notation. Indeed, it may be easily conceived that letters placed on syllables, to indicate sounds, could not be quickly understood; it was therefore found necessary to seek some more intelligible method. That which most naturally occurred was to place the letters at different degrees of height from each other, analogous to the elevation or depression of the voice, and to mark these degrees in a more accurate manner by means of parallel lines. This was the method employed before Guy, and he only simplified and regulated it. Instead of repeating the letter, Guy merely wrote it at the commencement of the line, and, whenever it afterwards occurred, simply put a dot in its place. Shortly after, he rendered this still plainer, by placing dots in the intervals of the lines; using these intervals to denote degrees, by which he reduced the distances from one note to another, and made the scale much easier to perform at sight. Guy likewise

added to the ancient system a bass note answering to *sol*, on the first line of the clef *Fa*; he designated this note by the *gamma* of the Greeks (Γ), and it is from this sign that the series of sounds in the system take their name of *gamut*. To these inventions he added another, that of counting by hexachords instead of tetrachords, and of designating by the syllables *ut, re, mi, fa, sol, la*, the *major* hexachord, upon whatever degree of the system it was placed: this was the foundation of his method of sol-faing which, however, it would be tedious to explain here. The invention of counterpoint is likewise attributed to him, though without any foundation. It is true he was one of the first who wrote on the subject, but he was not the inventor; for, although this art had made little progress, still it was known before Guy's time.

It may be proper to state that the organ was introduced into France in the year 757, and soon became universal in the churches of the west. It was directly used as an accompaniment to the voice. This accompaniment was at first entirely in unison; but the facility with which several sounds could be distinguished at once occasioned the remark, that, among the various union of sounds, many were agreeable to the ear. The minor third was one of the first remarked for its pleasing harmony, and was therefore generally used, though only at the close of an air; and this method was called *organizing*. There were likewise many other methods; for instance, holding on the sound of the organ on some note below the chant or singing part, or playing the air a fourth below or a fifth above, and frequently both together, which last was called *double organization*. Soon after, this method was adopted in singing without the organ; and from thence the terms *descant*, meaning double chant, *triple, quadruple, medius, motet, quintet, quartet*, &c., all of which preceded the term *counterpoint*. An uninterrupted series of authors anterior to Guy, as Notker, Remi of Auxerre, Hucbald, and Odon de Cluny, testify the origin and progress of this art, and historically demonstrate its being a modern invention, totally unknown to the ancients. Their writings, as well as those of Guy, and of J. Cotton (his commentator), are to be found in the valuable collection which the prince abbé Gerbert published under the title of *Scriptores Ecclesiastici de Musicâ Sacrâ potissimum*, &c.

The introduction of *time*, or the relative values of the notes in music, forms an important feature in its progress as a science. The first music divided into bars appeared about the beginning of the seventeenth century, though the system was not generally adopted till the eighteenth. The distance between the bars was in time diminished, till they enclosed but one measure, as in the present day; the only exception now being in the *à capella* time, namely, in two semibreves, with a quick movement, when the bars are still marked only every second measure, to avoid their too frequent repetition. The introduction of bars, with their gradual increase, has produced the natural result of bringing into disuse notes of great value; and at the present period the note of highest value is the semibreve, if we except the breve in *capella* time. As for the round and the maxim they are now no longer known, except by the musical antiquary. The form of the notes has likewise sustained an alteration, though scarcely worth noticing. Formerly, the head of the note was square; towards the middle of the seventeenth century they were formed round, or of an inclined oval; and in the course of 100 years the round became universal, and is the form retained up to the present time. Rhythm, as we have previously seen, has sustained but slight variation; but it has been quite the reverse with sounds, and consequently with harmony and counterpoint.

Till the close of the fifteenth century, the degenerated tones of the Greeks, as preserved in the chant of the Roman church, not only served as a foundation to ecclesiastical chanting, and to the works of composers who endeavoured to harmonize those chants, or to compose according to that system, but various profane songs of that time which we still possess, and some of which are to this day popular, appear to have partaken of the ecclesiastical modes. In the course of the sixteenth century, however, a movement appeared, which led the art to that state of perfection which it has now attained. To dispel whatever may appear vague or obscure in this remark, it is necessary to give a clear idea of what is meant in music by tone or mode, and subsequently to demonstrate the relations subsisting between the modern and ecclesiastical modes. No one endowed with the most ordinary musical organization, or capable of the slightest observation, can fail to have remarked the tendency that every musical piece has to terminate on some particular note or sound, for which no other could be substituted, without rendering the air incomplete. This experiment may be tried on the most simple tunes known. We say of a piece of music, It is in the *key* of such a note, when it ends on that note or sound, and which note is called the tonic or principal; now, if we decompose a piece of music which is supposed to be, throughout, in the same key, it will be found that it is composed of a certain number of different keys, each having a direct affinity to the principal key note. The *ensemble* or system of these affinities constitutes the *musical mode;* and if, from the tonic to the octave, we place all the intermediate sounds in regular succession, we shall form the scale of the mode. It is possible to imagine a great number of different modes, from which may be formed a variety of systems. Each of these systems of modes will constitute essentially the same number of idioms or musical languages, which will belong to various races of men. Thus the eastern nations appear to have had a system of modes quite different from ours, and, indeed, we have not to this day any very distinct idea of them. At the present day we have but two modes, namely, the major mode, the scale of which is contained in *ut, re, mi, fa, sol, la, si, ut;* and the minor mode, in which the ascending scale is *la, si, ut, re, mi, fa, sol, la;* and in descending, *la, sol, fa, mi, re, ut, si, la;* this is, at least, according to the notions at present existing, though there is still much want of precision and accuracy in the theory of this subject. However this may be, these modes are entirely modern, it being hardly more than 100 or 150 years since they have become prevalent, and to the extent of rendering it a doubtful question whether or not the modern nations of Europe can ever accustom their feelings to any other system of tones, and further whether all other such systems are not, for them, rather systems of modulation, that is to say, of concatenation of modes, than a *system* of modes, properly so called. The ancient contrapuntists

had an established and almost exclusive rule to add the third and fifth to all the notes of the scale, with the exception of that which bears the minor fifth, to which thy put the sixth: they looked upon all harmony as allowable which was exempt from a succession of fifths and octaves: but the doctrine of the new modes soon displayed the errors of this harmony, which formed an infinity of bad combinations, such as the sixth with the third, or frequently on many other degrees of the scale: it was on the above principle that Palestrina and all his school wrote.

A schoolmaster in Lombardy (Charles Monteverde), who flourished about 1590, invented the harmony of the dominant; he was also the first who used the seventh and even the ninth of the dominant; he likewise employed the minor fifth as a consonance, which had always before been used as a dissonance. Thus the tonal harmony became known; and, his principle being once admitted, all its consequences were naturally deduced, and musicians arrived almost insensibly at the conclusion that only three essential harmonies were to be acknowledged in the mode, namely, that of the tonic, of the dominant, and of the sub-dominant, which are all that should be placed, either direct or inverted, on these notes and on those comprised in their harmony. Charles Monteverde likewise introduced into composition double dissonances, which were soon succeeded by triple dissonances, and diminished and altered chords. It must naturally be supposed that counterpoint was in some degree affected by these innovations; it now became usual to employ intervals in melody which had till then been totally interdicted; and the intervals in harmony soon succeeded each other in a way till then unknown. About this time L. Viadana de Lodi formed the idea of giving to the instrumental bass a different melody from that of the vocal, to which it had previously strictly adhered; he further proposed to make this new bass reign throughout the piece, to consider it as the basis of the whole composition, and to represent by figures the chord it was to carry. In these points alone can he be considered as the inventor of fundamental bass; for it does not appear he in any way added to harmony. All these innovations excited the indignation of the masters attached to the ancient rules; but at length sense and experience overcame their vague and abstract reasonings. At first, indeed, these new methods were merely applied to profane and modern music, and the ecclesiastical chants continued to be formed on the ancient rules, somewhat mitigated, however, according to the method of Palestrina and the Roman school; but, towards the close of the seventeenth century, they began, in practice, to consider the church tones merely as a form to enchain or keep within bounds the modern tones, and according to this principle they applied tonal harmony to their ecclesiastical compositions. It is thus that the school of Naples, particularly Durante, considered the subject, and the modern tones are now universally acknowledged in church music. Practice has ever, in all the arts, preceded theory, or rather doctrine; and indeed it should always be thus, for doctrine should merely observe the operations of genius and reduce them to principles; it should not advance too quickly, thereby exposing itself to be contradicted by experience. If we examine the successive doctrines of the period we have been surveying, we shall find an additional proof of the truth of these observations. P. Aaron, L. Fogliani, and all those who wrote during the first two generations of the sixteenth century, added little to the improvements of the fifteenth. Zarlino, who published in 1571 his *Harmonic Institutions*, collected and developed all the theories and precepts established up to his time; and his work was then considered, and for long after, as the most eminently classical ever written on music. Far, however, was he from exceeding in knowledge the composers of his day, for he appears not to have heard of Palestrina, who flourished about 1552. All Zarlino's doctrine was established on the practice of the masters of the Flemish school, of whom he himself was a pupil. In this he was followed by Artusi, Zacconi, and others, who wrote towards the close of the sixteenth century. D. P. Ceroni, who published at Naples, in 1613, his *Melopeo y Maestro*, narrowed the boundaries of the doctrines of music. He modified his instructions according to those of Palestrina and other masters of the Roman school. Galeazzo Sabbatini, who, in 1644, gave rules for thorough-bass, wrote on the same principles. But it was not until we possessed the treatises of Bernardi, Buononcini, and Gasparini, towards the close of the seventeenth or commencement of the eighteenth century, that the practices in counterpoint introduced at the close of the sixteenth century were reduced into a theoretical system; from that time to this, these doctrines have remained nearly the same as they were established by the last-named authors. Towards the commencement of the eighteenth century, a French writer, M. Rameau, affirmed that all rules, up to his time, were merely blind traditions, without connection or foundation, and proposed reducing them to a few precepts, which he pretended to deduce from the laws of physics. As the opinions of this celebrated man have for some time been much in fashion in France, and have had a useful influence on certain points of musical doctrine, it may be proper to give some idea of them. If we examine the various chords used in accompaniment, we shall find they may all be traced to different combinations of certain groups of sounds. For example, the chords *ut, mi, sol, mi, sol, ut, sol, ut, mi,* are evidently but three combinations of the sounds *ut, mi, sol;* the chords *sol, si, re, fa, si, re, fa, sol, re, fa, sol, si, fa, sol, si, re,* are four combinations of the sounds *sol, si, re, fa,* in which each sound becomes successively the bass, the arrangement of the higher sounds being perfectly indifferent. Now, if we consider one of the chords which are composed of the same sounds as principal, the others may be viewed merely as dependents. With this idea the ancients were perfectly acquainted, and they considered that chord as principal in which all the sounds were placed at intervals of thirds, the remaining chords (composed of the same sounds) being inversions of the first. Some ignorant writers have attributed the origin of this idea to Rameau. In this they are mistaken, and to be convinced of their error they have only to glance at the writings of Zarlino, Bernardi, and others, when they will find that the above idea, which is indeed founded in truth, had long been familiar to the ancients. What may with truth, however, be attributed to Rameau is, his having endeavoured to include all the laws of harmony in those laws which govern the principal chords. To this end, he names these chords *fundamental chords;* the note which acts as bass he calls the *fundamental*

note; and finally he terms *fundamental bass* that hypothetical bass which is formed solely by the fundamental note. This being decided, he next proceeds to prescribe rules for the formation of this bass, or rather for the succession of fundamental chords; and, according to his doctrine, harmony will be regular whenever the chords of which it is formed, being brought back to their fundamental chords, offer successions in the bass correspondent to the rules which he has established. When the conservatory, established at Paris towards the close of the eighteenth century, determined, for the benefit of the pupils, to invent and adopt an elementary work, a professor of that establishment (Catel) proposed a treatise on harmony, which of all those hitherto published agrees best with the practice observed for nearly two centuries past. He considers as *natural* chords all such as are commonly termed consonances, also all dissonant chords used without preparation; he examines in a summary manner their principal successions, and demonstrates in what way, by means of the anticipations, retardations, and alterations of which they are susceptible, they produce all *artificial* chords or dissonances properly so called. This doctrine had been previously taught by the school of Durante, as we find from the small treatise of Fenaroli, entitled, *Regole per li Principiante*, &c., and was likewise established in Germany; but Catel produced it in a much clearer and more decided form, and it has been adopted in France by all able musicians: indeed it must be considered a most important step in the doctrine of harmony.

The subject of musical instruments, as a branch of scientific accompaniment, should be considered under two heads:—first, as to the sonorous principle which forms the basis of each one separately; secondly, as to the mechanism of execution. First, in respect to the sonorous principle, instruments are divided into stringed, wind, and vocal instruments, &c.; as relates to their mechanism, they may be divided into six classes, namely, bowed instruments, wind instruments, keyed instruments, stringed instruments, instruments of percussion, and, lastly, mechanical instruments. At the head of these six divisions must be placed the human voice, the first, the most beautiful of all instruments, and which serves as a model for the construction of every other.

Without entering into unnecessary detail, it will be sufficient to enumerate the instruments now most in use amongst those nations whose musical system resembles our own. These are, first, amongst bowed instruments, the violin, the viola or tenor, the violoncello or bass, and the double-bass; secondly, amongst wind instruments, the German flute, the clarionet, the hautboy, the bassoon, the horn, the trumpet, the trombone, the serpent, the fife, and the flageolet; thirdly, amongst keyed instruments, the piano-forte and the organ; fourthly, amongst stringed instruments, the harp, the guitar, the lyre, and the mandolin; fifthly, amongst instruments of percussion, drums of different kinds, and cymbals; sixthly and lastly, amongst mechanical instruments, the self-playing organ, *ælophon*, &c.

Instrumental music is nothing more than a melody or a system of melodies appropriated either to a single instrument or to several together. This leads us to consider it in two points of view: first, as single music; secondly, as concerted music.

Single music is that which is composed or adapted peculiarly for a single instrnment, whether it be, in fact, produced by that one instrument, or, in order to increase the effect, be accompanied by one or more additional instruments, they being entirely subservient to the principal. This music is the *solo* properly so called, and the *accompanied solo*, of which the *concerto* is the most brilliant style. There are as many styles of *solos* as there are of instruments; but, as it is impossible that we should enter into all the details which this variety presents, we shall confine our notice to the solo of the violin, which is regarded, and justly, as the first of all instruments.

Solos, whether simple or accompanied, comprehend, under the name of *studies, fantasias, capricci, sonatas, concertos*, &c., &c., an infinite number of pieces in various forms and styles. The construction of solos, whether simple or accompanied, comprehends their melodic form and the choice of instruments, both which objects have varied repeatedly previously to attaining their present degree of perfection. The form, indeed, is still constantly changing, so much so that there appears to be no fixed rule on this head. With regard to the selection of instruments, a subject that concerns the whole series of accompanied solos, from the sonata (which is the simplest of all) to the concerto, there have also been a vast number of changes. The sonata, in the course of the seventeenth century, was in many respects fixed by Corelli. The concerto was invented by Torelli, his contemporary, under the name of *concerto grosso*, and employed at first only five instruments, namely, the quartet and the leading part. F. Benda and J. Stamitz made the addition of wind instruments, forming it thus into a kind of symphony. In every thing relating to the execution of instrumental music, it is of the utmost importance to dispel a very common error which consists in believing that music was formerly very simple, and easily performed. This error arises from the circumstance of the old writers having made use of notes of very great value, and its not being remembered, at the same time, that these notes were executed with great rapidity, so that they had, in fact, no greater value than those in use at the present time. Besides which, if we cast our eyes upon the collections of pieces remaining to us from the preceding centuries—for example, upon the *Virginal Book* of Queen Elizabeth, published in 1578—difficulties will be found which would puzzle the most able of our modern performers.

There have been the same revolutions as to taste and style in instrumental music as in singing; it has indeed always been influenced by the existing style of vocal composition. Without referring to the periods anterior to the seventeenth century, concerning which we have little or no information, we know that, during the first two generations of that century, music was entirely in the madrigal style. When dramatic music began to prevail under Corelli, the contemporary of Perti, Colonna, and Scarlatti, it was scientific and rather dry; Geminiani first enriched it by expression, both as to composition and execution. Soon after this period the concerto, in particular, was greatly improved in the hands of the elegant Jarnowick and of the graceful Mestrino, both of whom were still surpassed by Violti, who gave to this style the character which seems so peculiarly his own, and brought it to a degree of perfection which it seems scarcely capable of exceeding.

All we have said concerning solos applies equally

to concerted music, by which term we understand instrumental music with different parts, in which all the instruments are equally obligato, either because each of them has its appropriate part or because each takes up the strain successively, the others alternately becoming accompaniments. These two methods are practised alike in the duet, the trio, the quartet, the quintet, and other pieces where each instrument has its separate part, and in the symphony, where all the parts are doubled for effect, according to justly determined proportions. Boccherini was the first who, in 1768, gave to the trio a fixed character; after him came Fiorèllo, Cramer, Giardini, Pugnani, and, lastly, Violti. It is also Boccherini who, at the same period, first fixed the *quartet;* he was followed by Giardini, Combini, Pugnani, and, in another school, by Pleyel, Haydn, Mozart, and Beethoven. Boccherini likewise about this time fixed the *quintet*, in which he has no rival but Mozart.

The symphony, improved since the middle of the same century, by Gossec, Toeski, Wanhall, and Emmanuel Back, was perfected by Haydn, who, following the steps of Bach, brought this branch of music to a degree of superiority till then unknown, and which has since become, for his followers, a model scarcely to be equalled. (See SINGING, and the various musical instruments in their alphabetical order.)

Music, Sacred. Almost all nations who have an established religious service have made music an important part of it; and, in a general sense, we might give the name of *sacred* music to all music employed in religious festivals, even before the Christian era, as that of the Egyptians, Hebrews, Greeks, and Romans, as well as to the religious songs of the bards and scalds. The early Christians, who were led by various passages in their sacred writings to employ religious songs, introduced at their religious meetings (particularly in the Eastern churches) the singing of the psalms and hymns which are to be found in the books of the *Old Testament*, and to which the Jewish converts had been already accustomed in their assemblies. They sang also at the Lord's supper and at the agapes. At the synod of Laodicea (364), regular songs were introduced, which were sung from notes by persons appointed for this purpose. The Western churches received through Ambrosius, bishop of Milan, a regular church music, similar to the Eastern. Probably this possessed a regular modulation and rhythm, only that both were defective through the imperfection of the music at that time; the latter appears to have been limited to long and short tones; the former was founded upon the Grecian modes remaining in Italy, and was very poor. Perhaps many of the melodies of Grecian and Roman hymns now received words adapted to the religious worship of the Christians. The Christian fathers bear witness to the use of songs in the Christain communities in the first century, and many of them, as Ambrosius and Augustine, were great admirers of them.

In regard to the manner of singing in the first assemblies, it was sometimes in solo, sometimes alternately, and sometimes there was a chorus of the whole assembly, who united in repeating short passages, before sung or read, from which, probably, the female sex was at first excluded. For the regular ordering of the singing, precentors were instituted in the fourth century, who were considered as inferior officers of the church. Schools appropriated to singing were instituted later, and only in a few places Pope Gregory the Great (590—604) distinguished himself in the Roman church as the founder of a new singing school, in which boys were instructed. It was the model of many other institutions of this kind. In consequence of this education of persons for singers, the singing was not only more artificial, but the people were also for the most part excluded, particularly as the hymns were in Latin. Gregory collected in his *Antiphonarium* the existing songs of the church, which he selected from the best ancient melodies, improved and increased by the addition of new ones.

The *Gregorian Chant*, so called after him, was sung in unison with loud notes of similar value, with rhythm and metre (by which it is particularly distinguished from the Ambrosian), or in the old Grecian modes, but with a more complex modulation. This Gregorian or plain chant, which, by means of Gregory and his successors, has been extended throughout the west, is the foundation of the Christain church music. It was also called *choral song*, because it was sung by a choir. The Gregorian Chant was afterwards adopted both in England and France. Charlemagne, who laboured particularly for its diffusion, caused several singing schools to be established in France, and united them with the monasteries. The Gregorian Chant was probably introduced into Germany by Boniface, but it was first generally diffused there in the time of Charlemagne. The developement of the music for four voices may have been assisted by the choral; but musical instruments contributed yet more thereto, as well as to the formation of perfect harmony; among these, the organ particularly, which soon took the first rank in the churches. Now figured music arose, and likewise figured song, which, in the fifteenth century, began to become general, as the custom grew up of varying, extending, and embellishing the accompanying voices of a melody, while the chief voice, upon which the fundamental melody depended, remained unchanged (hence it was called *cantus firmus, canto fermo*, plain-chant); but still the chief voice often became the under voice. This happened afterwards, also, with melody. The invention of measured music caused the choral to be performed in a more regular measure, and gave greater extent to harmony. Choirs of singers now became necessary, and singing was often applied, especially in Italy, to heighten the splendour of religious worship. (See ITALIAN MUSIC.)

The organ was continually improved, after the fifteenth century, and other instruments, also, were introduced into the church, against which complaints were often made, as well as against the new figured music in general, which found peculiar support in the instrumental music. Yet these complaints were chiefly directed against the abuse of the figured and instrumental music, and they were not able to banish them from the church. The fifteenth and sixteenth centuries form a new period of church music, which was extended by the great masters in Italy, France, the Netherlands, and Germany. Luther's services to the German church music are well known, for which he laboured, by means of his friend Senffel. During the seventeenth and eighteenth centuries, church music became continually more brilliant and always more corrupted by the intermixture of profane music. In the Roman Catholic church, the sacred music is confined to fixed forms of text; for instance, the text

of the mass, the *Offertoria*, *Te Deum*, *Salve*, *Requiem*, *Psalms*. In the Protestant church, poets and composers allow themselves new forms.

MUSK. This valuable article in the materia medica comes to our country in round thin bladders, which are generally about the size of a pigeon's egg, covered with short brown hairs, lined with a thin brown membrane, well filled, and without any appearance of having been opened. The musk itself is dry, with a kind of unctuosity, of a dark reddish brown or rusty blackish colour, in small round grains, with very few hard black clots, and perfectly free from sandy or any other visible foreign matter. If chewed and rubbed with a knife on paper it looks smooth, bright, yellowish, and is free from grittiness. Laid on a red-hot iron it catches flame and burns almost entirely away, leaving only an exceedingly small quantity of light grayish ashes. The largest and fullest bag seldom contains more than two drams of musk. Its taste is somewhat bitter, and its smell extremely powerful and peculiar. Neumann got from thirty grains of musk twelve of watery and four of alcoholic extract; and, inversely, ten of alcoholic and six of watery. Its smell and taste were elevated in distillation with water, but not with alcohol. Neither the fixed nor volatile oils dissolve it.

The very great price of musk has given rise to many modes of adulterating it. To increase its weight, sand, and even particles of lead, are introduced through very small openings into the bags. The real musk is frequently abstracted from the bag and its place supplied with dry blood coarsely powdered, or some mixture with asphaltum. These adulterations are to be detected by discovering that the bag has been opened. The presence of blood is also known by the fetid smell it emits when heated sufficiently, and by the formation of ammonia when rubbed with potass. Asphaltum is known by its shining fracture and melting on hot iron, while musk is converted into charcoal. But there are even artificial bags filled with a composition containing some real musk. These are in general thicker and covered with longer hair, and want the internal brown membrane which lines the real musk bag.

Musk is said to be a medicine of very great efficacy, and one for which, in some cases, there is hardly any substitute. When properly administered it sometimes succeeds in the most desperate circumstances. It raises the pulse without heating much; it allays spasms, and operates remarkably on the brain, increasing the powers of thought, sensation, and voluntary motion.

It may be employed in every instance of typhus fever, especially when attended with delirium, or spasmodic affection of any particular organ or of the whole system, or subsultus tendinum, &c. It is also used with the greatest benefit in exanthematous and phlegmonic diseases, accompanied with typhoid fever; and in many spasmodic affections, as chincough, epilepsy, trismus, &c.

It is most conveniently given in substance in powder, in doses of three grains or upwards, repeated every one or two hours. Its best preparation is the tincture.

MYRRH; a gum resin. The best myrrh is brought from Troglodytitia, a province of Abyssinia, on the borders of the Red Sea; but what we receive comes from the East Indies, and is produced on the eastern coast of Arabia Felix.

The best myrrh is in the form of tears, of a yellow or reddish yellow colour, becoming redder when breathed on; light, brittle, of an unctuous feel, pellucid, shining; presenting white semicircular striæ in their fracture; of a very bitter aromatic taste, and a strong, peculiar, not unpleasant odour. It is not good if whitish, dark-coloured, black, resinous, ill-smelled, or mixed with impurities, which is too commonly the case.

Neumann ascertained that water and alcohol are both of them capable of taking up the whole of the taste and smell of the myrrh, the extract made by either after the other being insipid. The alcohol distilled from the tincture elevated none of the flavour of the myrrh; but during the inspissation of the decoction a volatile oil arose, containing the whole of the flavour of the myrrh, and heavier than water, while the extract was merely bitter. From 7680 parts of myrrh, he obtained 6000 watery extract, 180 volatile oil, and 720 alcoholic: and, inversely, 2400 alcoholic, and 4200 watery. Braconnot found that myrrh chiefly consisted of a gum, differing from all others. 1. It acquires cohesion by heat, which renders it partly insoluble in water, when the solution is evaporated; 2. It furnishes ammonia by distillation, and azote with nitric acid. 3. It precipitates lead, mercury, and tin, from their solution. Myrrh also contains 2.3 parts in 100 of a bitter, very fusible, resinous matter. I have observed that the tincture is transparent, and when poured into water forms a yellow opaque fluid, but lets fall no precipitate, while the watery solution is always yellow and opaque; and that myrrh is not fusible, and is difficultly inflammable. Mr. Hatchett found it soluble in alkalies.

Vauquelin obtained from the root of the *Andropogon Schoenanthus*, by means of alcohol, a thick brown oil, having an acrid, burning taste, like an essential oil, and exactly the smell of myrrh. It differs from myrrh chiefly in having less solidity; but Vauquelin thinks that if it were united to a gummy matter it would exactly resemble it. He does not suppose, however, that this is the plant which produces the myrrh of commerce, but considers it as a proof that myrrh is formed in various vegetables.

Myrrh is a heating stimulating medicine. It frequently occasions a mild diaphoresis, and promotes the fluid secretions in general. Hence it proves serviceable in cachectic diseases arising from inactivity of the system, and is supposed to act especially upon the uterine system, and to resist putrefaction.

It is employed medicinally, in the form of powder, or made up into pills, in doses of ten to sixty grains. 2. Dissolved in water, as in Griffith's celebrated but unchemical myrrh mixture; and 3. Dissolved in alcohol.

NACRE, or MOTHER OF PEARL, is the inner part of the shell of the pearl muscle. This is of a brilliant and beautifully white colour, and is usually separated from the external part by aqua-fortis, or the lapidary's mill. Pearl muscle shells are on this account an important article of traffic to China and many parts of India, as well as to the different countries of Europe. They are manufactured into beads, snuff-boxes, buttons and spoons, fish and counters for card-playing, and innumerable other articles. The pearl muscles are not considered good as food; though, after having been dried in the sun, they are sometimes eaten by the lower classes of people in the countries near which they are found.

NAIL-MAKING. The art of preparing metallic bolts or pins for building. Formerly, the nail-maker's process was very tedious, every nail being made by the hand, and each begun and finished by the same individual; it was afterwards discovered in this manufacture, as in many others, that by the division of labour, and by assigning to different persons the pointing, heading, &c., a greater quantity of work was done by the same number of hands; of course the processes were much simplified and expedited, and the article could be sold on much lower terms.

Since the commencement of the present century, ingenious mechanics have not only improved the method of manufacturing nails, but have thought it expedient to secure to themselves the exclusive right of their inventions by obtaining the king's letters patent: of some of these we shall proceed to transcribe an account from the *Circle of the Mechanical Arts*:—

In the year 1790 Mr. Thomas Clifford, of the city of Bristol, obtained two patents for the manufacture of nails of every kind. The principle on which his first invention is founded is that of making the nails in a die; that is, by having a die or the impression of the nails to be cut, composed of one or more pieces of iron. The iron of which the nails are to be formed is drawn and rolled into the proper form and thickness, and, by a force adapted to the purpose, is pressed into the cavity or die so as to form the nails, either complete or so nearly complete as that they can be finished with a very little labour. This operation may be done in several ways, but the one particularly recommended by Mr. Clifford is by rollers of iron or steel, and worked by water, steam, wind, horses, &c. The two rollers are to be made of iron and cased with steel, each of the same diameter, and the diameter proportioned to the length and size of the nail intended to be made. Each roller should have one or more cog-wheels, the cogs of one roller to work into those of the other, so that the rollers may both perform the same exact revolution. One half of the impress of the nail is to be cut with one roller, the other half with the other, so that the two impressions form a cavity or die of the exact form of the nail, extending the lengthways of the nail on the circumference of the rollers; and as many impressions of the same kind may be cut in the rollers, one at the end of the other, as will complete the circumference, and continue the cavity all round the rollers, the point of one nail joining the head of the next, or the two points and two heads joining each other. The rollers must in this, as in other cases, be made to work very true, and close to each other.

The mode of operation is this:—A rod of metal, iron for instance, rolled or drawn to a convenient size, is to be heated, and, while hot, the end of it is put between the rollers, into the cavity or die which forms the impression of the nail. The rollers, being now put in motion, will draw the iron through, pressed into the cavity which forms the impression of the nail, the one jointed to the other, which must be afterwards separated by means of instruments acting as nippers, shears, chisels, &c. The rollers being made to work very close to each other, where the edge of the nail is formed, will prevent much of the metal from being pressed out on each side of the nail, and what is pressed out may be cut off by instruments adapted to the purpose. Several pairs of rollers may be made to work together, and each pair may have several rows of dies cut on them, so as to form the impression for several strings of nails; and a rod of iron, being put into each of them, will roll out as many strings of nails with one revolution of the rollers. A pair of rollers may also have the greater part of their surface cut with dies, and a flat bar or piece of iron be made to pass between the rollers, so as to form sheet nails; the whole of them connected with one another by thin plates of iron, of which they are composed, and this would require each nail to be cut out or separated from the sheet by proper instruments.

Mr. Clifford's second invention consists, 1. In drawing the iron, or other metal, into a tapering wedge-like form, according to the length and thickness of the different sizes of nails to be made. 2. The nails are to be cut out of those wedge-like plates, by means of a punch, the face of which is made according to the size, taper, and form of the nail to be cut out; as also, having a hollow bolster, the hollow or aperture of which must also be made of the size and form of the nail, and consequently to fit and receive the punch above mentioned. The punch thus fitted to the bed, and sliding in the frame to keep it steady, will, by a blow or by pressure, cut or force a part of the taper-plate into and through an aperture of the bed fitting to it, and by which the nail is formed. This operation is, by the manufacturers of buttons, buckles, &c., generally called cutting out. 3. To form the heads of horse-nails, called rose heads, and others of nearly a similar kind, after the operations of drawing and cutting out, the nail is to be put into a heading tool, which is also called a bed, which bed receives the nail, excepting a small portion at the thick end of which the head is formed by a punch. This punch, by a blow or pressure, forms the head as required; and, when the nails are made of hard iron, after they are cut in the way described, the thick end is made hot before they are put into the bed or heading tool. Another method adopted in the manufacture of nails is by cutting them out of iron plates of equal thickness, and afterwards pointing them either by a hammer or other pressure. In making nails that are of a triangular form, the plate or strip of iron is pressed into a die, having impressions to the form of such nails, after which they are cut out by a punch.

At about the same period in which the foregoing patents were obtained, Mr. William Finch, of Woombourne, in Staffordshire, invented another method of making nails and spikes by machinery, to be worked by steam, &c., by which all manual labour was to be saved. In his specification he describes his power as consisting of one main shaft, caused to revolve in either a horizontal or perpendicular direction by means of a water-wheel or a steam-engine. Such main shaft will put in motion, by means of cog and pinion wheels, other countershafts or barrels, on which are fixed arms, &c., and on these are hammers that are worked in either a lift or a tilt manner. He also makes three divisions of hands in the manufacturing of headed nails, namely, one man, woman, or child, stationed before the hammer, which person, by mere activity, will with one hand not only form the larger size nail, but a far greater number in the same given time: when the third person will, with the same kind of hammer, head and finish a great number of the same shanks together, leaving them truer made,

and better for use than by the old mode. Also, by a division of hands, the same apparatus will make such nails as require no tool or frame to be headed in; namely, the one to carry the iron from the fire, and the other stationed before the hammer to finish them. In enumerating the advantages and savings of this method, above the others then in use, Mr. Finch says that, by heating many rods in one fire, there will be a saving of coal: by the more speedy motion of machine hammers, several nails will be made by once heating the rod, whereas by the old method only one is made: again, the motion being regular, independently of strength, a child will be able to make the largest nail or spike. (See SCREWS.)

NANKEEN, or NANKING; a sort of cotton cloth, which takes its name from the city of Nanking, where it was originally manufactured. It is now imitated in most other countries where cotton goods are woven; but those of the East are superior, on account of the natural colour of the cotton (*gossypium religiosum*) being reddish, while in those countries where white cotton is used it is necessary to give it the proper hue by artificial means.

NAPHTHA, a liquid bitumen. It is very light, of a pale yellow-green colour, transparent, thin, and liquid. It is highly inflammable and volatile. It is intimately connected with the following bodies: petroleum, or mineral tar, which is semi-liquid, often of a thicker consistence, tenacious, semi-transparent, of a reddish-brown colour, and fœtid odour. Maltha, which is solid, but soft, has a degree of tenacity, and a strong bituminous smell. Its colour is black, its lustre highly resinous. It is sometimes elastic, forming what has been named the elastic bitumen. Asphaltum is the last of the series, and forms the connection with pitch coal. It is of a black colour and resinous lustre, without transparency; its fracture is conchoidal; it is light, and has a bituminous smell when rubbed or heated. It melts easily, takes fire, and burns without leaving any ashes. Through all these substances there is a perfect gradation; naphtha, by inspissation, becoming petroleum, and this, by the same operation, passing into asphaltum; and even the different specimens of these are frequently found in the same situation. They also agree in their chemical characters, are inflammable, insoluble in water and in alcohol, but combine with fixed and essential oils, and are partially soluble in ether. They are not dissolved by the alkalies, and are decomposed by the more powerful acids.

Petroleum is at present very rarely employed as a medicine; though, if the finer kinds could be procured genuine, they seem to deserve some notice. They are more agreeable than the oil of amber, and milder than that of turpentine, of the virtues of both of which they participate. They are principally recommended by authors for external purposes, against pains and aches, in paralytic complaints, and for preventing chilblains. For these purposes, some of the more common mineral oils have been made use of with good success. An oil extracted from a kind of stone-coal has been extolled among the common people, under the name of British oil, for rheumatic pains, &c.; even this is often counterfeited by a small portion of oil of amber added to the common expressed oils.

The Barbadoes tar is found in several of the West India islands, where it is highly esteemed by the inhabitants as a sudorific, and in disorders of the breast and lungs; though in inflammatory cases it is improper.

NAPLES YELLOW, a dye, is prepared by exposing lead and antimony with potash to the heat of a reverberatory furnace. It stands tolerably well, but turns black upon the contact of iron. A native pigment of this kind is also obtained from a species of lava.

NARD, among the Greeks and Romans; a sort of aromatic oil; and also a sort of plant. Pliny mentions several species of the latter. The ancients were accustomed to anoint themselves with nard at their feasts. In the Scriptures the use of it is also mentioned (*John* xii. 3, and *Mark* xiv. 3), where different substances seem to be intended.

NATRON; a salt which is found in the ashes of several marine plants; in some lakes, as in the natron lakes of Egypt; and in some mineral springs, &c. (See SODA.)

NAUMACHIA, among the Romans; a public spectacle, representing a naval action. Cæsar was the first who exhibited a spectable of this sort, which soon became the favourite amusement of the Roman people. The *circus maximus*, in which they were at first represented, being found inconvenient, buildings were erected by the emperors, particularly calculated for the purpose: these edifices were likewise called *naumachiæ*. They resembled the amphitheatres, and, like them, were at first built of wood. Domitian appears to have been the first who erected one of stone. A *naumachia*, built by Augustus, was 1800 feet long and 200 wide, and was capable of containing fifty ships with three banks of oars, besides many small vessels. They were suddenly laid under water by means of subterraneous canals, so that the ships were raised at once from the dry floor before the eyes of the spectators. The water was usually brought from the Tiber, near which the *naumachiæ* were generally built, but sometimes from aqueducts. The *naumachiarii*, or persons who fought in these exhibitions, were gladiators, slaves, criminals, &c., who were doomed to die, unless they were saved by the interposition of the people, or of the person presiding at the show.

NAVAL ARCHITECTURE. The commerce and political existence of Great Britain in a great measure depend on the scientific skill displayed by our artisans in ship-building. Prior to the close of the last century but little attention was paid to the principles of flotation and displacement, on which the science of the subject may be said to rest. Now, however, we have regular academies where young men are educated for the purpose. In these establishments they acquire a perfect knowledge both of the theory and practice of ship-building, and there is no doubt but that the results of such a system of education will be highly advantageous to our marine force.

The navy of England does not date its origin prior to the time of our Saxon ancestors. It is now, however, the best defence for our sea-girt shores. The navy may indeed be considered as the natural strength of the British empire, nor need we apprehend any danger from foreign invasion while Britain retains the sovereignty of the seas. To ensure this important desideratum, the art of ship-building must receive that assistance from theoretical science without which foreign navies will ultimately excel us on our own peculiar element.

The first authentic testimony which we find of the existence of a navy in this country occurs at the in-

vasion of Normandy by Henry, surnamed Beauclerc, in the year 1106; and the crusading expeditions, which immediately followed, contributed, in some degree, to cherish the embryo giant in its youth. Selden has given the event just mentioned as the æra of the first assertion on the part of Britain to the right of what is called the dominion of the sea; and adduces, in proof, the orders given by Henry to his Butescarli, or sea officers, that they should take particular care no vessels from Normandy approached the English coast.

The variety of improvements and inventions which took place during the fourteenth and fifteenth centuries, tended to render general nautical knowledge much more respectable than it had been. To the invention of the compass is most probably owing the discovery of America. To that of cannon, and their introduction into ships, may be attributed those improvements in naval architecture which distinguish a modern ship of war from the ancient galley.

The celebrated Sir Walter Raleigh, speaking of the ability and knowledge possessed by the British shipwrights, observes, "To say the truth, a miserable shame and dishonour it were for our shipwrights, if they did not exceed all others in the setting up of our royal ships, the errors of other nations being far more excusable than ours; for the kings of England have for many years been at the charge to build and furnish a navy of powerful ships, for their own defence, and for war only; whereas the French, the Spaniards, the Portuguese, and the Hollanders, till of late, have had no proper fleet belonging to their prince or state."

To render our description of the modern improvements in ship-building intelligible to the reader, it will be necessary for us to examine what naval architecture was in ancient times.

The vessels used on the Nile appear to have been formed of small planks cut out of the acantha or Egyptian thorn: these were not, as might be naturally supposed, cut into lengths, as planks, but nearly square, measuring about three feet each way; they were lapped over each other like tiles, and fastened together by a proper number of wooden pins nearly of the same shape with the trenails of modern times. This mode of construction was found sufficiently strong for the purposes to which it was applied, even without the obvious assistance of any internal frame of timber, and, proving equal to the necessities and ambition of the inventors, they for a long time troubled not themselves with attempting any additional improvement.

The hull of the vessel being completed, a competent number of seats, or benches, for the accommodation of the rowers, were added; and when the joints or seams were carefully caulked with the papyrus, so as completely to exclude the water, the floating fabric become fit for immediate use. We must not, however, forget to mention that experience very easily suggested the necessity of some directing as well as impelling power, in aid of human labour. A mast formed out of a straight stick of the acantha, and a sail made of papyrus, supplied the latter; at the same time a rudder, which is said to have passed through the keel or bottom of the vessel, remedied the defect occasioned by the want of the former.

As the Egyptian vessels are the earliest of which any well authenticated graphic illustration has been preserved, we give at *fig.* 1, *plate* I. NAVAL ARCHITECTURE, a view of one of their earliest sailing vessels from a bass-relief. An Egyptian vessel of the present day is represented at *fig.* 2, and beautifully illustrates the difference between the naval architecture of ancient and modern times.

Among a people so destitute of ambition as we find the Chinese described, little variation could be expected to take place either in ship-building or any other art connected in the most distant way with war, and extension of territory, since that time when experience taught them that their different rude contrivances fully answered the humble ends to which they were applied. On comparing the account given by Sir George Staunton of their smaller vessels with those in use among the aboriginal Britons, their similitude will be found extremely striking. "The boats," says he, "commonly in use among them, consist of five planks only, joined together without ribs or timbers of any kind. These planks are bent to the proper shape, by being exposed for some time to a flame of fire. They are brought to a line at each end, and the edges are joined together with wooden pins, and stitched with bamboo split into flexible threads, and the seams afterwards smeared with a paste made with quick-lime from sea shells and water. Others are made of wicker-work, smeared all over, and rendered water-tight by the same composition as is used for the former. The owners affect to paint eyes upon the heads of all these boats, as if to denote the vigilance requisite in the conduct of them. They are remarkable for standing the sudden shock of violent waves, as well as for being stiff upon the water, and sailing expeditiously. The boat belonging to the chief of the district was built upon the same plan, but upon a larger scale; it had a carved and gilt head, bearing some resemblance to that of a tiger, and a stem ornamented with sculpture and painted with a variety of designs in lively colours. In these boats the principal sitters are generally at the stem, instead of being near the stern, as is the custom in Europe."

The Chinese are said, by modern travellers, to build vessels which trade as far as Manilla, Japan, and Batavia, the burthen of which frequently amounts to 800 or even to 1000 tons. All well-informed writers agree, as already stated, that no alteration has been made in the naval architecture of this extraordinary people for several centuries past; and it has excited their wonder, in no small degree, that though Canton is visited by the ships of various nations, the superior construction of which, it might be apprehended, must be necessarily acknowledged, yet they have never thought proper to adopt any improvement whatever in the art. It is rational, however, to believe that if no innovation has been made in the form and rigging of their vessels the size and burden of them have been nevertheless permitted to increase with the spirit of trade and foreign commerce which the example of Europeans cannot but have diffused. This supposition will reconcile the account just given of the tonnage of the modern Chinese vessels with the seemingly contradictory authority of former visitors, from whom it has been understood that the capacity of the Chinese vessels, or junks, never exceeded 300 tons. A Chinese vessel similar to those employed by that people for more than 2000 years is shown at *fig.* 3, *plate* I. NAVAL ARCHITECTURE.

The keel is reported to have been generally omitted during the early ages of navigation; in vessels

Fig. 1

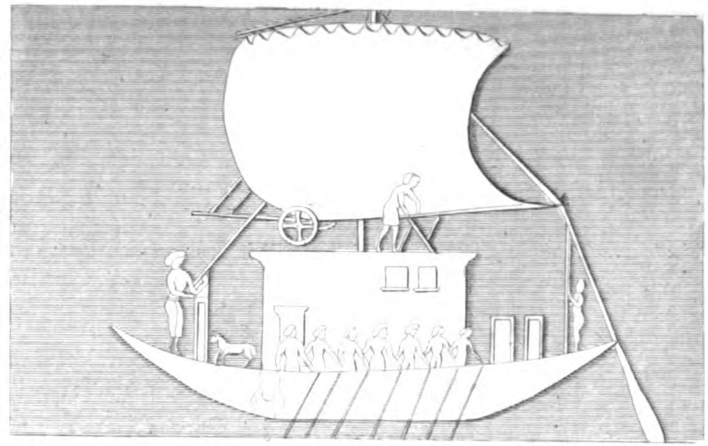
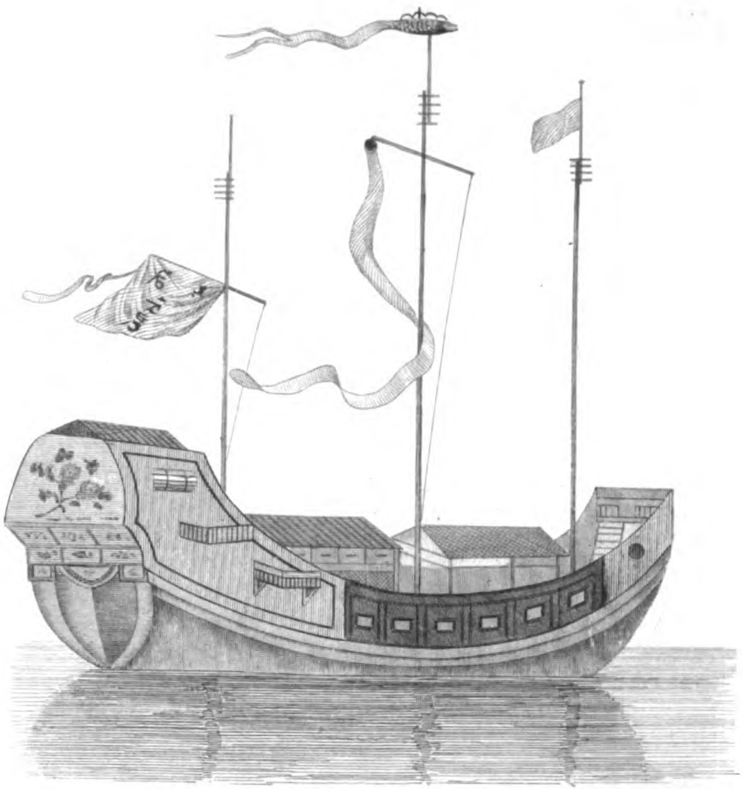


Fig. 2

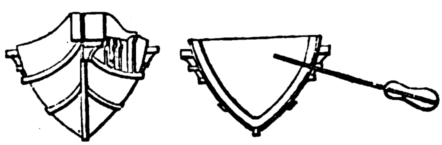
Fig. 3



London. Published by Orr & Smith, Paternoster Row, Nov. 20, 1838.

intended merely for commercial purposes. The form of these, from the most authentic descriptions, appears to have borne greater similitude to those at present employed in the same line among the Dutch than to any others now in use. They were flat-floored, round, broad, drawing little water, and of very great breadth in proportion to their length, so that they might be capable of containing a greater freight than would be the case under the adoption of any other form. Their floor-timbers were continuous; and with the addition of one futtock only on each side (called by the Greeks the ribs, from that portion of the animal body) the frame was completed.

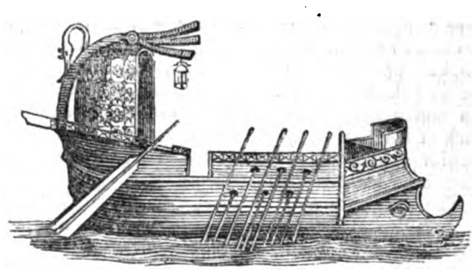
Some persons, indeed, have gone so far as to assert that by a peculiar mode, known only to the ancients, the timber was rendered so flexible that the frame was formed of one piece only. This secret, however, appears to have been nothing more than bringing it by force into its proper curve, and either confining it till time had in a great measure subdued its elastic efforts to regain its original and naturally straight form, or, as a more expeditious method, by adding cross-pieces, now called beams, and bolting them strongly to the timbers, thus completing the vessel by one uninterrupted operation. This practice being soon found extremely laborious and inconvenient was quickly discontinued with regard to vessels of burthen, and the keel universally and indiscriminately applied to them, as well as to vessels of war. To the keel, improvement and subsequent experience suggested the addition of the keelson, which, confining the heads of the floor-timbers, then in two parts, jointed and divided by the keel, very materially contributed to the strength and safety of the vessel. Close to the keelson was the well, contrived as the receptacle for the bilge-water which the working of the vessel through the rough sea caused the admission of, and which, from the impossibility of closing the joints or seams completely by caulking, found its way in in considerable quantities. The part immediately above the keelson was called the hold, and from thence is derived the English word keel, which forms the bottom of it. Aloft, beams were fixed, as already stated, which served to strengthen the vessel, and support that necessary covering well known by the name of deck. The complete arrangement of the interior of one of these ancient vessels will, however, be best understood by a sectional view.



One figure represents the galley taken at midships, and the curve formed by the timber frame is creditable to the talent of their naval architects. The other figure serves to show the forms of the head and stern of the galley.

The principal dimensions of different classes of vessels in use among the ancients, as well as of those which were of such extraordinary magnitude as to be extremely uncommon and rarely constructed, have been transmitted to posterity with much apparent certainty and precision. The celebrated Egyptian vessel called the Isis is said to have been in length 180 feet, in breadth forty-five, and in height, from the upper edge of the deck to the bottom of the well, forty-three feet. The well known ship of Hiero, king of Syracuse, was of nearly 4000 tons burthen. The rules of construction in general use for those which were usually employed in commerce, after the art had progressively advanced toward what was then supposed perfection, were in the following proportion: supposing the breadth twenty-five feet, the length was 100. The galleys which were intended entirely for the purposes of war were twice that length, but of the same breadth; nor can that very extensive difference be deemed incredible, or even wonderful, when it is known that, even in modern times, vessels no less extravagantly proportioned have been built for particular purposes, and have proved by no means ill adapted to them.

In the accompanying engraving we give a view of a second-rate Roman galley.



Meibomius gives the following dimensions of these vessels: "They were," says he, "in length 125 feet; in breadth eleven; but according to new regulations, adopted after the time of Julius Cæsar, they were built only ninety feet in length, and ten in breadth. The Quadrireme was 125 feet long, and thirteen broad: the height of the Octoreme (as the same author asserts) measured, from the upper surface of the deck to the lower edge of the keel, eleven feet: the Hexereme nine." Their first requisite was swiftness: on that principally depended the success of all their naval encounters; and every other quality was of little consequence to them. For this reason, the minds of those ingenious men who considered the science of constructing vessels as a national art, which the well-doing of their country particularly demanded should be carefully cultivated, were constantly applied to the discovery or advancement of some improvement. As soon as it was practically found that the narrowness of their vessels contributed, in a great degree, to their swiftness, and this established as a fixed and invariable principle, the next care was to dispose the rowers so commodiously within the vessel that they might not, in the first place, impede each other in their motions, and, in the second, that no part of the side should be left vacant where it was possible to employ or work an oar. The attainment to this degree of perfection is attributed to the Sidonians; and the variety of the different services which repeated warfare created gave birth to all those different classes into which the ancient galleys were divided.

Curtius gives a very circumstantial account of a fire-ship, equipped by the Tyrians at the time their capital was besieged by Alexander. "Having selected," says the author, "one of the largest galleys

they possessed, they loaded it by the stern, with stones and other ballast, so that the prow became considerably elevated above the surface of the water. The whole of the vessel which was above water was thickly coated with sulphur, and other substances easily inflammable, which operation being completed, advantage was taken of a wind favourable for the attempt, and all the sails being set the crew, who in aid of the sails made use of their oars also, directed it towards the mole which Alexander had with so much difficulty laboured to construct. When they had approached sufficiently near to the destined object of destruction, the vessel was set on fire, and the crew jumped into boats which had followed for the purpose of receiving them." This project, at that time new in theory as well as practice, proved completely successful: the hopes of Alexander were frustrated, at least for a time, and every trace as to the labour of so many thousand men vanished almost in an instant, for the whole of the stupendous work was completely destroyed. Nor was it on such an occasion alone as the preceding that these destructive engines of war, as they might without impropriety be styled, were used. Various were the occasions on which they were employed, especially in the attack of fleets when lying in harbour; for in this particular application of them the ancients appear to have been most expert.

The following account given of a Scottish ship of war may stand as the summary history of the northern royal navy:—

"The king of Scotland rigged a great ship called the Great Michael, which was the largest and of superior strength to any that had sailed from England to France; for this ship was of so great stature, and took so much timber, that, except Falkland, she wasted all the woods in Fife, which were oak wood, with all timber that was gotten out of Norway; for she was so strong, and of so great length and breadth, all the wrights of Scotland, yea, and many other strangers, were at her device by the king's command, who wrought very busily in her, but it was a year and a day ere she was completed. To wit: she was twelve score foot of length, and thirty-six foot within the sides; she was ten foot thick in the wall and boards, on every side so slack and so tight that no cannon could go through her. This great ship cumbered Scotland to get her to sea. From that time that she was afloat, and her masts and sails complete, with anchors offering thereto, she was counted to the king to be thirty thousand pounds expense by her artillery, which was very great and costly to the king by all the rest of her orders. To wit: she bare many cannon, six on every side, with three great bassils, two behind in her dock and one before, with three hundred shot of small artillery, that is to say, myand and battered falcon, and quarter falcon, flings, pestilent serpentens, and double dogs, with hagtor and culvering, crossbows and handbows. She had three hundred mariners to sail her; she had six score of gunners to use her artillery, and had a thousand men of war by her, captains, shippers, and quarter-masters."

We may now proceed to the practical part of our subject, which is in fact of the greatest importance. Stability and "flotation" are the first and principal points which strike the consideration of the naval architect; and, of these, stability evidently claims precedence, even before flotation or speed, because the safety of the human race depends on the former, and only the political or pecuniary advantage of it on the latter. Supposing a vessel drawing six feet water, and having a length of keel amounting to forty feet, it is too evident to need explanation that such a vessel must make infinitely more leeway than if it drew twelve feet, or was eighty feet in length, the lateral resistance being increased according to the squares of the side or surface presented to the water. From this cause is derived the reason why vessels of great length are less apt to make leeway than those which are shorter. The hope of increased advantage may, however, be productive of evil in some respects, provided the system be not properly confined within reasonable bounds. The inconvenience to be dreaded is material, and may be attended with the worst consequences. The reason is easily demonstrable in plain and very few terms. The action of the rudder, and its influence on the motion or course of the vessel, are exactly that of the lever; and, if the hull becomes extended to an immoderate length, the force of such lever is gradually weakened and less capable of effecting its office, till, in the end, it becomes totally useless; so that unless its own power be increased by an extraordinary addition, which would be inconvenient, or if very far augmented impracticable, on account of the power required to govern and regulate it, the ship will become the sport of the winds and waves, refusing to obey the wishes and will of its pilot.

To remedy this inconvenience, vessels were introduced having an exceedingly narrow breadth of floor, and built in every respect what is termed sharp; so that, by their sinking considerably lower beneath the surface of the water than those of flatter construction, they might, though much shorter, continue to present the same face, in square inches or feet, to the fluid as a lateral resistance, and consequently be rendered equally as little liable to fall to leeward. This system of construction is, however, pregnant with quite as many inconveniences as the former. It experiences infinitely more resistance, in the first instance, in its passage through the water; its very contracted capacity, in proportion to its measurement and expense of construction, renders it inconvenient and unadvisable, even as a vessel of war, and totally incompatible with the ideas as well as interests of commerce. Added to these considerations is that scarcely less consequential objection arising from its great draught of water, its incapability of sailing where vessels of a flatter construction would pass with safety, and the extreme danger to which it would be exposed in case of touching the ground, even in that slight degree which would be unattended with apprehension in the instance of a flat-floored vessel.

If we compare the hull of a ship to the skeleton of the human body, the keel may be considered as the backbone, and the timbers as the ribs. The keel therefore supports and unites the whole fabric, since the stem and stern posts, which are elevated on its ends, are, in some measure, a continuation of the keel, and serve to connect and enclose the extremities of the sides by transoms, as the keel forms and unites the bottom by timbers. The keel is generally composed of several thick pieces, placed lengthways, which, after being scarfed together, are bolted and clinched upon the upper side. When these pieces cannot be procured long enough to afford a sufficient depth to the keel, there is a strong thick piece of timber bolted to

the bottom thereof, called the false keel. The figure of vessels is an object of great importance, with regard to their motion, sailing, &c.; and, in the determining what form is most commodious, the doctrine of infinites becomes of apparent service to navigation and commerce. A body moving in an immovable fluid is obliged to sever the parts thereof: and they resist such separation.—Now, setting aside a certain tenacity, by which they are, as it were, glued together, and which is different in different fluids, the whole force of the resistance depends on that of the shock or impulse, for a body that is struck may be said to strike at the same time; but a perpendicular stroke is that which a fluid resists the most readily, and for a body to move freely therein it must be of such a figure as to present itself as obliquely as possible. If it were triangular, and moved with the point foremost, it is certain all its parts would strike the fluid obliquely: but they would all strike it with the same obliquity; and it were more advantageous that each should strike more obliquely than the next adjacent. Now, such a perpetual augmentation of obliquity can nowhere be had but in a curve line, each point of which is considered as an infinitely small right line, always inclined to the other little right lines contiguous to it. These brief observations will account for the curvilinear figure assumed by all perfect vessels, the form and proportions of which we may now proceed more particularly to explain.

When it is proposed to build a ship, the proportional size of every part of her is to be laid down, from which the form and dimensions of the timbers, and of every particular piece of wood that enters into the construction, are to be found. As a ship has length, breadth, and depth, three different plans at least are necessary to exhibit the form of its several parts; these are usually denominated the sheer-plan, the half-breadth-plan, and the body-plan.

The *sheer-plan* or *draught*, otherwise called the plan of elevation, is that section of the ship which is made by a vertical plane passing through the keel. Upon this plan are laid down the length of the keel; the height and rake of the stem and stern posts; the situation and height of the midship and other frames; the place of the masts and channels; the projection of the head and quarter-gallery and their appendages; and in a ship of war the position and dimensions of the gun-ports. Several imaginary lines, namely, the upper and lower height of breadth lines, water lines, &c., are also drawn on this plan.

The *half-breadth* or floor plan, or, as it is frequently called, the horizontal plane, contains the several half breadths of every frame of timbers at different heights; ribands, water lines, &c., are also described on this plane.

The *body-plan*, or plane of projection, is a section of the ship at the midship-frame or broadest place, perpendicular to the two former. The several breadths and the particular form of every frame of timbers are described on this plane. As the two sides of a ship are similar to each other, it is therefore unnecessary to lay down both; hence the frames contained between the main frame and the stem are described on one side of the middle line, commonly on the righ-hand side, and the after frame is described on the other side of that line. Several lines are described on these planes, in order the more readily to assist in the formation of the timbers, the principal of which are the following:—

The top-timber line is a curve limiting the height of the ship at each timber.

The top-timber half-breadth line is a section of the ship at the height of the top-timber line, perpendicular to the plane of elevation.

The height of breadth lines are two lines named the upper and lower heights of breadth. The lines are described on the plane of elevation to determine the height of the broadest part of the ship at each timber, and, being described in the body-plan, limit the height and breadth of each frame at its broadest part.

The main half-breadth is a section of the ship at the broadest part, perpendicular to the sheer-plan, and represents the greatest breadth at the outside of every timber.

Water-lines are lines supposed to be described on the bottom of a ship, when afloat, by the surface of the water, and the uppermost of these lines, or that described by the water on the ship's bottom when sufficiently loaded, is called the *load water-line*. According as the ship is lightened, she will rise higher out of the water; and hence new water-lines will be formed. If she be lightened in such a manner that the keel may preserve the same inclination to the surface of the water, these lines will be parallel to each other; and, if they are parallel to the keel, they will be represented by straight lines parallel to each other in the body-plan; otherwise by curves. In the half-breadth plan, these lines are curves limiting the half-breadth of the ship at the height of the corresponding lines in the sheer-plan. In order to distinguish these lines, they are usually drawn in green.

Riband lines are curves on a ship's bottom by the intersection of a plane inclined to the plane of elevation, and are denominated diagonal or horizontal, according as they are measured upon the diagonal or in a direction perpendicular to the plane of elevation. Both these answer to the same curve on the ship's bottom, but give very different curves when described on the half-breadth plan.

Frames are circular pieces of timber bolted together and raised upon the keel at certain distances, and to which the planks are fastened. A frame is composed of one floor-timber, two or three futtocks, and a top-timber on each side, which, being united together, form a circular enclosure, and that which encloses the greatest space is called the midship or main-frame. The arms of the floor-timber of this frame form a very obtuse angle; but in the other frames this angle decreases with the distance of the frame from midships. Those floor-timbers which form very acute angles are called *crutches*. The length of the midship floor-timber is in general about half the length of the main-frame.

A frame of timbers is commonly formed by arches of circles called *sweeps*. There are generally five sweeps. 1. The floor-sweep, which is limited by a line in the body-plan perpendicular to the plane of elevation, a little above the keel; and the height of this line above the keel at the midship-frame is called the *dead-rising*. The upper part of this arch forms the head of the floor-timber. 2. The lower-breadth sweep, the centre of which is in the line representing the lower height of breadth. 3. The reconciling sweep. This sweep joins the two former, without intersecting either, and makes a fair curve from the lower height of breadth to the rising line. If a straight line be drawn from the upper edge of the keel to touch the back of

the floor sweep, the form of the midship-frame below the lower height of breadth will be obtained. 4. The upper-breadth sweep, the centre of which is in the line representing the upper height of breadth of the timber. This sweep described upwards forms the lower part of the top-timber. 5. The top-timber sweep is that which forms the hollow of the top-timber. This hollow is, however, very often formed by a mould, so placed as to touch the upper-breadth sweep, and pass through the point limiting the half-breadth of the top-timber.

We may commence by giving the dimensions of a ship of war, proposed to carry eighty guns upon two decks.

	Feet.	Inches.
Length on the gun or lower deck from the aft part of the rabbet of the stem to the aft part of the rabbet of the post	182	0
Length from the foremost perpendicular to dead-flat	63	11¾
Length from the foremost perpendicular to next timber	4	0
Length from after perpendicular to timber thirty-seven	3	4
Room and space of the timbers	2	8¾
Length of the quarter-deck from the aft part of the stern	95	0
Length of the forecastle from the fore part of the beak-head	49	0
Length of round-house deck from the aft part of the stern	51	8
Height of the gun or lower deck from the upper edge of the keel to the under side of the plank at dead-flat	24	0
Height of the gun or lower deck from the upper edge of the keel to the under side of the plank at foremost perpendicular	26	0
Height of the gun or lower deck from the upper edge of the keel to the under side of the plank at after perpendicular	26	3
Height from the upper side of the gun-deck plank to the under side of the deck plank, all fore and aft	7	0
Height from the upper side of the upper deck plank to the under side of the greater deck plank — afore.	6	10
— abaft.	6	11
Height to the under side of forecastle plank afore and abaft	6	6
Height from the upper side of the quarter-deck plank to the under side of the round-house plank — afore.	6	9
— abaft.	6	10
Height of the lower edge of the main wales at foremost perpendicular	24	6
Height of the lower edge of the main wales at dead-flat	20	0
Height of the lower edge of the main wales at after perpendicular	26	6
Height of the lower edge of the channel wales at foremost perpendicular	32	6
Height of the lower edge of the channel wales at dead flat	29	0
Height of the lower edge of the channel wales at after perpendicular	34	0
Height of the upper side of the wing-transom	28	4
Height of the touch of the lower counter at the middle line	33	5
Height of the touch of the upper counter at the middle line	36	2

	Feet.	Inches.
Height of the top-timber line at the after part of the stern timber	44	7
Main wales in breadth from lower to upper edge	4	
Channel wales in breadth from lower to upper edge	3	0
Waist rail in breadth	0	7
Distance between the upper edge of the channel wales and the under edge of the waist rail	2	9
Sheer rail in breadth	0	6
Distance between the sheer rail and the rail above, from timber thirteen to the stern	2	5
Distance between the sheer rail and the rail above, from timber seven to timber eleven	1	4
Distance between the sheer rail and the rail above to the forepart of beak-head	1	2
And the said rail to be in breadth	0	6
Plank sheer to be in thickness	0	2½
Centres of the mast.—From the foremost perpendicular to the centre of the main-mast on the gun-deck	103	2
From the foremast perpendicular to the centre of the foremast on the gun-deck	20	5
From the after perpendicular to the centre of the mizzen-mast on the gun deck	28	6
Height of ditto from the upper edge of the keel	26	1
Stem moulded	1	3
Foremost part of the head afore the perpendicular	2	4
Height of ditto from the upper edge of the keel	38	3
Aft part of the rabbet afore the perpendicular on the upper edge of the keel	3	4
Aft part of the port abaft the rabbet at the upper edge of the keel	2	6
Aft part of the port abaft the rabbet at the wing-transom	1	1
Stern-post fore and aft on the keel	3	1
Ditto square at the head	2	0½
The touch of the lower counter at the middle line, abaft the aft part of the wing-transom	7	6
Round aft of the lower counter	1	4
Round up of the lower counter	0	9
The touch of the upper counter at the middle line abaft the aft part of the wing-transom	9	9
Round aft of the upper counter	1	3½
Round up of the upper counter	0	10
Aft part of the stern-timber at the middle line, at the height of the top-timber line, abaft the aft part of the wing-transom	12	6
Round aft of the wing-transom	0	6
Round up of the wing-transom	0	5½
Load draught of water from the upper edge of the keel — afore.	20	5
— abaft.	20	5
The channel to be in length	37	0
And in the thickness at the outer edge	0	4½
The dead-eyes to be twelve in number, and in diameter	1	6
Foremost end of the main channel afore timber	0	10
The channel to be in length	38	0
And in the thickness at the outer edge	0	4½

NAVAL ARCHITECTURE.

PLATE II.

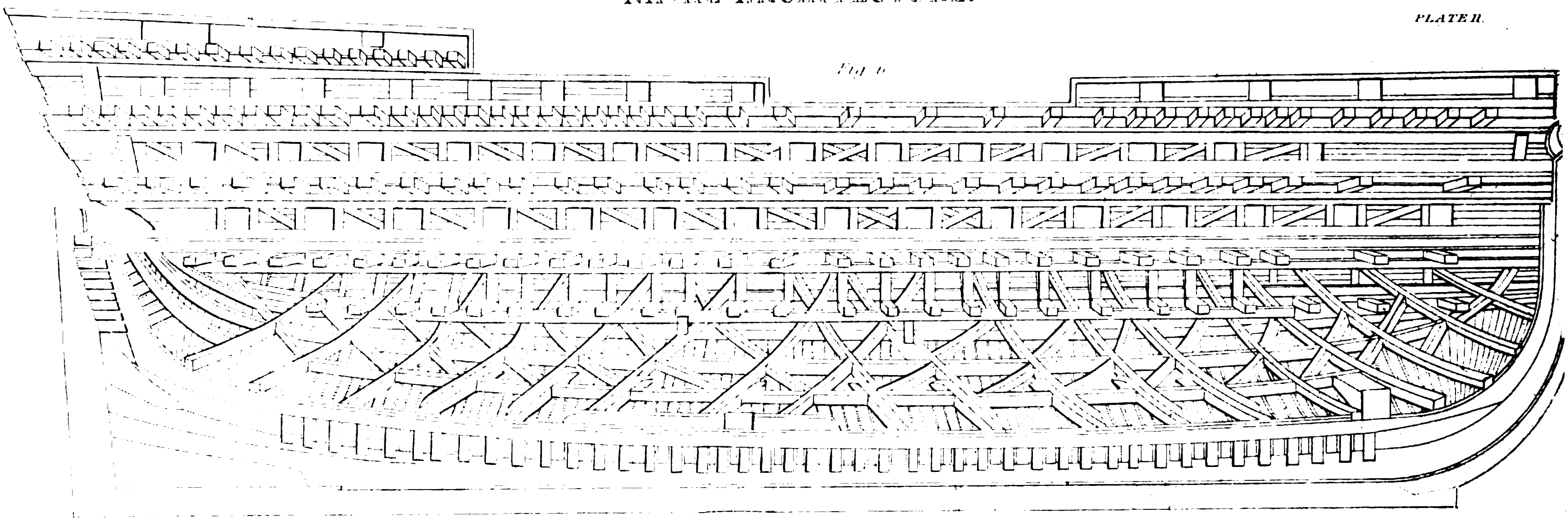


Fig. 6.

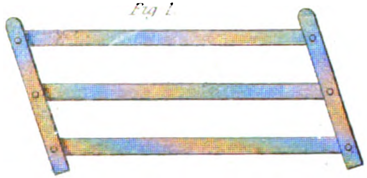


Fig. 1.

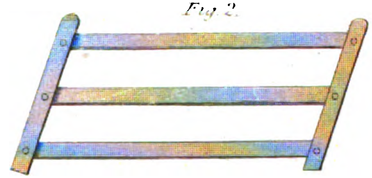


Fig. 2.

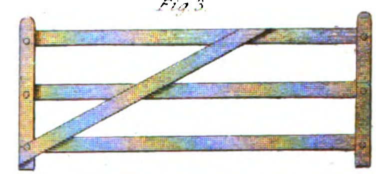


Fig. 3.

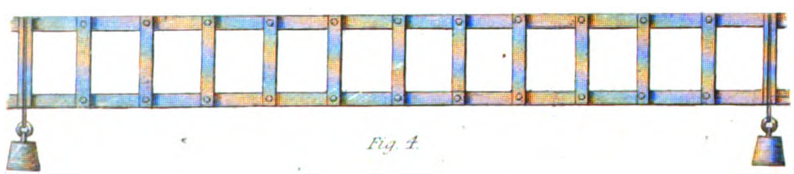


Fig. 4.

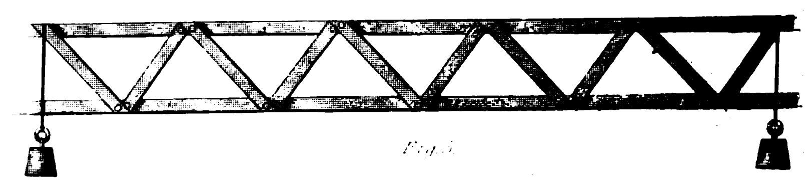


Fig. 5.

	Feet.	Inches.
The dead-eyes to be fourteen in number, and in diameter	1	6
Foremost end of the mizzen channel abaft timber twenty-seven	2	4
The channel to be in length	20	0
And in thickness at the outer edge	0	4
The dead-eyes to be seven in number, and in diameter	1	0

Having in the previous table given the relative proportions of every part of a ship of war constructed in one of his majesty's dock-yards, we come now to what may be considered as a new era in the art of ship-building. Sir Robert Seppings, to whom we are indebted for some of the most important improvements in marine architecture which have characterized the present century, claims a prominent place in our pages, and the elaborate calculations by Dr. Young will form the best supplement to his ingenious labours.

Several large ships have already been built on the principle about to be explained; and, from the favourable reports of those ships, the Lords of the Admiralty have given their orders for the building of other ships upon the same principle.

To show, in as clear a light as possible, the advantages of the application of this new principle to ship-building, it may be necessary, for the information of those who are not acquainted with that art, to give the following general outline of the structure of a ship on the old principle.

1. The frame of a seventy-four-gun ship is formed of more than 800 different timbers, placed at right angles to the keel, which may be considered as the back-bone of an animal, and the frame timbers as its ribs. Each rib is composed of several pieces of the thickness of fourteen inches, or thereabouts. Between the several divisions of the frame, or ribs, is a space from one to five inches wide.

2. The exterior frame is covered with planks of different thicknesses, or, to carry on the figure, the ribs are covered by a skin of greater or less substance from the extreme ends of them to the keel or back-bone. The inside of the frame is also almost entirely lined with planks, within which is another partial range, as it were, of anterior ribs, at a considerable distance from each other, termed riders.

3. Across this frame are pieces of timber called beams, united together so as to be of sufficient length to reach from one side of the ship to the other. The use of these beams is to secure the sides of the ship, so as to prevent her upper works from spreading, and to keep that part which is under water from being compressed by the fluid. They are also the supports or bearers of the decks (or what we call in houses the girders for the floors), and must therefore be of such strength as to endure the weight of the cannon, and whatever else is to be placed upon them. The mode of fastening these to the sides has, generally speaking, been merely local, by two angular pieces of timber or iron (called knees) bolted to each beam, and also to the sides of the ship, by which means they were only partially held to the side, and there was wanting that continuity of materials, and consequently of strength, which the new system gives.

Between the beams and at right angles with them are placed pieces of wood called *carlings*, and at right angles with these (consequently parallel to the beams) ledges, which correspond with joists in a house. The planking or flat of the deck (flooring) is laid nearly in parallel lines from head to stern, upon and at right angles with the beams, and is fastened to them and to the carlings and ledges by bolts, nails, or wooden pins called *trenails*. From this statement it will appear evident that the decks, according to the old construction, are in nowise connected with the sides of the ship.

Having thus briefly described the common mode of ship-building, it will next be proper to point out such of its defects as the new principle tends to remove.

In the first place, it will be perceived that all the materials composing the fabric of a ship are disposed nearly at right angles to each other. This disposition, which in every wooden fabric is well known to the humblest mechanic to be the weakest, is particularly so in a ship, the immense body of which, subject to violent action from impulses in every direction, is sustained by a greater pressure on the centre than the extremities, arising chiefly from the difference in the fore and after parts of the body to that of the midship, or middle part.

From the want of a continued succession of support from the centre to the extremities originates the tendency to arching, or hogging. This tendency shows itself in a ship from the moment of her launching; from which some idea may be formed as to the extent to which it will be carried in a troubled sea, when in the act of pitching she is borne up by the fluid only in her central part, while the head and stern are forsaken, and therefore unsupported by the water.

If a straight line be drawn from the head to the stern of a ship, whilst on the slip or in the dock, no sooner has she entered her own element than each end of this line will be found to have dropped from two to five or six inches, in consequence of the weakness of the fabric, and the two extremes wanting the quantum of support which the fluid gives to the central part.

The length of a seventy-four-gun ship being between 100 and 200 feet, it requires but little knowledge of the strength of timber to perceive that planking of that length, however thick, or in whatever way joined or put together, must, under the present system, bend with its own weight. The fastenings, and consequently the connection of the several parts of the fabric, must therefore suffer for the want of *stiffness*, and a change of form is the consequence. This may be shown by putting together four pieces of wood, and securing them with iron pins in the form of a square, which on the least pressure may be made to change its form to the rhombus; but let another piece be fixed to it diagonally, and the figure of the frame will be found immovable. Place a bar in the middle parallel to two of the sides, and secure it firmly by iron pins, still the figure will easily be moved by the hand, like a parallel ruler, and assume the rhomboidal shape of *fig.* 1 or 2. *plate* II. NAVAL ARCHITECTURE; but apply to the frame what the carpenters term the brace in a common field-gate as shown at *fig.* 3, and the figure will remain as before immovable. If this brace or diagonal piece is not fixed to it, the outer part of the gate (or that part most distant from the hinges) will have a constant tendency downwards, until at length it will reach the ground.

Let *figs.* 4 and 5 represent two frames of wood composed of parts strongly connected by bolts and iron pins.

Fig. 4 will represent the principle on which the present system of ship-building is conducted.

Fig. 5 the new principle.—Now if we attach two weights for the purpose of ascertaining the comparative strength or stiffness of each frame, it will be seen that the stiffness of *fig.* 5 is to that of *fig.* 4 as 6 is to 1, and the strength as 3 to 1.

The greater the length of the frames, the greater will be the advantages of the new principle, both in stiffness and strength.

The substitution of the triangle, as in the frame of *fig.* 3, for the rectangle in the frame *fig.* 1, comprehends the principle of the new system, the use and advantages of which will be sufficiently evident.

The arrangement of the materials in the triangular mode is such that the pieces disposed horizontally are acted upon as ropes are by a strain of the fibre, whilst the other parts, composing a series of triangles, are pressed upon as pillars: in other words, the pressure acts in the direction of the fibres of the wood; whereas upon the rectangular, or old plan, the fibres are acted upon transversely, or across the grain, in the same manner as a stick is when placed across the knee and pressed by the hands at each end, which first bends, and then breaks.

To prevent any transverse action upon the fibre of the timber is one of the benefits arising from the new system, and to impede a longitudinal extension of the structure is another.

For as the diagonal frame, composed of a series of triangles, aided by diagonal trussing between the ports, prevents the fabric from being acted upon transversely to the fibres of the materials horizontally placed, so the wales, the planking, the shelf-pieces, the improved waterways, and the deck systematically secured, become the tie-beams of the structure. In a word, the system of triangles is so constructed, in conjunction with the planking of the ship, as conjointly to possess that property of a triangle already explained, viz. that its figure is as unalterable as the compression or extension of the fibre of timber will admit it to be.

The strength of the principle has hitherto been considered as applying to or resisting an alteration of the figure, by giving great stiffness. It is now to be taken in another point of view, that of rendering the strength of the fabric as general and united as possible. For, let it be again observed, the strength of any body is but equal to that of its weakest part.

In the new system, the openings between the ribs are filled in with slips of timber nearly to the height of the orlop or lower tier of beams, which being then caulked, and peyed or pitched over, make the frame from head to stern, and within a few feet of the greatest draught of water, one compact and water-tight mass of timber; so that, were any of the outer planking of the bottom to be knocked off, the ship would not only still keep afloat, but would be secured from sinking. In the old system the starting of a plank would be and often has been fatal.

The mode of filling in these openings between the frame, where the width of the space does not exceed three inches, is by driving in slices of wood cut wedge-like; two of these being driven, one from the outside, the other from within, form the parallel space of the opening, thereby bringing the parts into the closest contact. In the openings exceeding the width of three inches, the space is occupied by pieces corresponding with the openings, the fibre of such pieces being laid in the same direction as that of the frame-timbers. These fillings occasion no consumption of useful timber, as one-fourth of the produce of slab and other useless wood now sold as fathom wood, would supply a sufficient quantity for the consumption of the whole navy.

The advantages obtained by filling in the openings are these:—To add to the strength and durability of the fabric; to preserve the health of the crew from the effects of the impure air arising from the filth which soon collects in these openings; to render the ship less liable to leakage, as well as to facilitate the stoppage of any leak; and, lastly, to increase, as it may be said, the thickness of the bottom from four inches or four and a half (the usual thickness of the plank) to about sixteen, thereby lessening very considerably the danger to be apprehended from getting on shore, or foundering at sea. That it tends also to the durability of the ship will be inferred from the following positions:—

1. That the openings on the old principle are, after a ship has had any considerable length of service, choked up in many parts with an accumulation of filth.

2. That no free circulation of air can be obtained in these openings by any means.

3. That timber being either freely exposed to the air, or entirely excluded from it, is equally preserved.

4. That it has been found, on examining the frame and plank of old ships, that those parts (now filled in) generally decay sooner than the rest, viz. from the floor-heads in the midships, and from the dead-wood forward and abaft, to the height of the orlop clamps.

If the above positions be true, it will follow that by filling in these openings much will be added to the durability of the ship, which also will be further promoted by omitting in these parts the inside plank, leaving thereby the surface of the frame-timbers exposed to a free admission of air as often as the ship's hold is unstowed, and, by filling in, excluding the air from two of the sides of every timber.

By omitting the inside plank, much is added to the internal capacity of the ship's hold. For though the trussed frame projects from the timbers more by five inches than the thick stuff at the floor-heads, yet, as in the old system the perpendicular riders are brought upon the thick stuff, their projection into the hold is more by eight inches than that of the new; the advantage therefore as to stowage is in favour of the diagonal frame. A tier of iron ballast will also be disposed of on this principle many inches lower, whereby an increase of stability will be given with less weight, which will favour the ship in carrying her ports out of the water, inasmuch as greater stability will be given with less ballast.

An accurate conception of the state of the ship's hold may be formed by referring to the longitudinal section (*Plate* II. *figure* 6) of the internal part of one side of a seventy-four-gun ship in a complete state, with fillings in the openings between the timbers of the frames instead of the planking over them. In this state the diagonal timbers are introduced, intersecting the timbers of the frame at about the angle of forty-five degrees, and so disposed as that the direction in the fore is contrary to that of the after part of the ship (as may be seen in the engraving), and their distance asunder from six to seven feet or more, their upper ends abutting against the hori-

zontal hoop or shelf-piece of the gun-deck beams, and the lower ends against the limber strakes, except in the midships, where they come against two pieces of timber placed on each side of the keelson for the purpose of taking off the partial pressure of the main-mast, which always causes a sinking down of the keel, and sometimes to an alarming degree. These pieces of timber are nearly as square as the keelson, and fixed at such a distance from it as that the main-step may rest upon them. They may be of oak or pitch-pine, and as long as can be conveniently procured. Pieces of timber are next placed in a fore and aft direction over the joints of the frame-timbers at the floor and first futtock-heads, their ends in close contact with and coaked or douelled to the sides of the diagonal timbers. In this state the frame-work in the hold presents various compartments, each representing the figure of a rhomboid. A truss-timber is then introduced into each rhomboid with an inclination opposite to that of the diagonal timbers, thereby dividing it into two parts. The truss-pieces so introduced into the rhomboid are to the diagonal frame what the key-stone is to the arch; for no weight or pressure on the fabric can alter its position in a longitudinal direction, till compression takes place at the abutments, and extension of the various ties. This arch-like property of the diagonal frame not only opposes an alteration of position in a longitudinal direction, but also resists external pressure on the bottom, either from grounding or any other cause, because no impression can be made on its figure in these directions without forcing the several parts of which it is composed into a shorter space. The connection which is kept up by means of this trussed frame firmly attached to the timbers of the ship by circular coaks and bolts, together with the shelf-pieces united to the sides and to the several beams by means of the same sort of fastenings, gives such unity to the whole as to bear no comparison with that heterogeneous and badly connected mass of materials for which it is substituted.

It has hitherto been a generally received opinion that stiffness or inflexibility in a ship is not strength, but that a yielding or bending of the fabric is an essential quality to preserve it from being destroyed by the shocks which it is destined to sustain. This misconception must have arisen from an equally incorrect idea, which is, that a ship must be an elastic body because there is a degree of elasticity in the materials of which it is composed. But it should be remembered that this elasticity of the materials is in fact very inconsiderable, inasmuch as the minute degree of elasticity in each piece is neutralised in the fabric by the various directions and tendencies of the numerous parts of which it is composed, so that a ship, let her construction be what it may, either loose or firm, is not in any case elastic. It follows, then, that every action and reaction of the sea operating upon different parts of the fabric at different times occasions, for the want of unity of the whole of the parts, a constant and increasing weakness, which by some may have been taken for elasticity.

When a sea strikes a ship forward, the bow will rise with the sea, which, passing aft, lifts the midships in succession, leaving at this time, in a great measure, the fore and aft parts of the ship with comparatively little or no support. Such shocks, acting upon a body whose parts are not firmly connected, produce a bending and rebending of the fabric, so that the several planks of the sides play over each other, and the fastenings are strained and loosened by a repetition of this action and reaction. On the contrary, when a body is constructed with such general unity and fixedness of all its parts as that if one be moved the whole must move with it, then it may be said that all the parts of the structure bear their portion of the strain.

The decks come next under consideration, the beams of which are disposed in the new system nearly as usual, except that in midships, where a ship necessarily requires the greatest security, two additional beams have been introduced. The beams of the several decks are attached to the ship's side in the following manner:—

1. By shelf-pieces or internal hoops. These shelf-pieces are composed of several lengths of timber scarfed or joined together by coaks, or circular douels, so as to form a kind of internal hoop, extending from the hooks forward to the transoms abaft, to the under side of which, as well as the under parts of the beams, they are securely coaked, and, being then firmly bolted to the side, instead of becoming a mere local fixture of the beam to the ship's exterior frame, as the knees were, they form one continued and general security. The shelf-piece is also a tie to the top side in a fore and aft direction, co-operating with the trussed frame, as already explained.

2. By chocks, which are placed under all the shelf-pieces in wake of the beams, except the orlop, in such a manner as to receive the up and down arm of the iron knees. The lower ends of those under the gun-deck shelf-piece rest on the ends of the orlop beams, and those of the several decks above rest on the projecting part of the spirketting below. The chocks, particularly those between the orlop and gun-decks, admit of their being driven into their respective places very tight, thereby acting like pillars. Another advantage attending them is their great tendency to stiffen the ship's side, and to prevent the beam ends from playing on the fastenings when the ship is rolling, or straining under a press of sail.

The flat or planks of the several decks being, on the old system, each of them a mere platform, or, in other words, a cover to a box unconnected with the sides, are here not only so disposed of as to oppose an alteration of figure from a force acting on the ship in a lateral direction, but are also made subservient in securing the beams to the sides of the ship.

The framing and flat of the decks (excepting the quarter-deck, forecastle, and round-house, which are laid upon the old plan) are disposed of, as represented in the plate, the former, that is, the framing or ledges and beams, in lines, the latter or planks in black, those of the starboard side being laid contrarywise to the larboard. The midship ends of the diagonal planks abut against two strakes laid in a fore and aft direction outside the comings of the hatchways; the other ends approach the timbers of the frame, and the buts at each end are secured to a tier of carlings placed for that purpose. The flat or plank of the deck so disposed is connected with a certain number of coaks to the hooks, beams, and transoms. When the decks are thus laid, waterways, as already described, are brought upon and coaked to the ends of the plank. These waterways being then bolted through the ship's sides, and also,

in an up and down direction, through the flat and shelf pieces, combine the whole in one homogeneous mass of great strength.

Few ships are without some complaint of apparent weakness after three or four years' service. These defects, which principally show themselves at the beam ends, proceed in a great degree from the local attachment of the beams to the ship's side, and the flat or covering being altogether unconnected, as already explained. The extreme ends of the beams, not being properly secured, play and work upon the fastenings, so that it is not unusual to see the bolt-holes cut to an oval figure by the friction of the bolts. The remedy usually applied to a ship in this state is to load her with additional materials, such as iron knees, standards, breast-hooks, &c., thus adding greatly to the original weight of the fabric. Now it is evident that with the first gale of wind the ship encounters, after being thus partially strengthened, she must be reduced to the same state of weakness she was in before the remedy was applied. This mode of strengthening ships may be compared to that of a raft firmly secured in the first place by strong lashing, which after some time works loose, or rather by working is stretched. As it might be too tedious a business to secure the raft by re-tightening the lashing, a small cord, or some twine, would be used to answer the purpose. It is clear that whilst the small cord or twine remained tight no part of the strain could bear upon the strong but loose lashing, till the other stretched or broke; so it is with a ship that has additional securities given her without refastening those which had worked, or were much strained.

The tendency of the ship to stretch or draw asunder in her upper works being by no means obviated by the short planks on the inside, between the ports, a truss-piece of plank is substituted in lieu of them, which, being well secured at the abutments, very materially aids the trussed frame, and gives stiffness, thereby opposing the inclination to arch or hog aloft.

Those essential qualities of strength, safety, and durability, having been detailed, a few observations with respect to the *economy* of the new principle may not be misplaced. Though this is only a secondary consideration, yet, as the royal navy cannot be kept up without a supply of foreign timber, it evidently becomes a subject of considerable moment, when we recollect that upwards of 180 oak trees might be saved in a seventy-four, and a greater number in larger ships, allowing each tree to measure a load, or fifty feet rough contents. The consumption of this scarce article might be further considerably lessened in the new system by the use of inferior and old ship timber, which cannot be employed in the other; and if old ship timber were to be generally introduced, as was done in the Ramillies, one-seventh part of the English oak required for a new seventy-four-gun ship might be saved. The facility of ascertaining the state and making good the defects of the frame in the lower part of the ship, in consequence of omitting the inside planking, will also occasion a considerable saving of timber and workmanship: indeed the great ease with which any part of the diagonal frame may be replaced justifies the making use of fir timber, particularly for the longitudinal pieces and trusses. But, should the well-grounded hopes of durability be realized, the saving of timber, and indeed of every article required for this enormous branch of the national expenditure, would be great indeed.

Sir Robert Seppings concludes his paper by observing that the appointment of most excellent and meritorious officers to the ships already completed on his principle may be considered as a most favourable circumstance towards ascertaining the real merits of the construction. Indeed, the orders for carrying this new principle of constructing His Majesty's ships into effect were directed by such an honourable spirit of liberality, and so unshackled was the authority given to enable Sir Robert to carry his plans into execution, that no subterfuge could have availed him had any failure been found in the system.

The advantage derived from the employment of forces acting obliquely with respect to each other, in a variety of cases which occur in practical mechanics, has been demonstratively established by theoretical writers on the subject, and attempts have often been made to extend the application of the principle very considerably in the art of ship-building, but hitherto with very little permanent success. Sir R. Seppings's arrangements are in many respects either new or newly modified. The question respecting the best disposition of the timbers of a ship is by no means so easily discussed as may be supposed by those who have considered the subject but superficially; and, if we allowed ourselves to be influenced by a few hasty arguments or experiments, we might be liable to the most dangerous errors: on the other hand, it may easily happen that objections which may occur at first sight to the application of those arguments or experiments may be capable of being removed by a more minute investigation; and the importance of the subject requires that no assistance which can be afforded by the abstract sciences should be withheld from the service of the public, even by those who have no professional motives for devoting themselves to it.

The first consideration that is necessary for enabling us to judge of the propriety of any arrangement respecting the construction of a ship is to determine the nature and magnitude of the forces which are to be resisted; and the second is to enquire in what manner the materials can be arranged so as best to sustain the strains which these forces occasion.

The principal forces which act on a ship are the weight of the whole fabric with its contents, the pressure of the water, the impulse of the wind, and the resistance of the ground or of a rock; and we must endeavour to ascertain the degree in which any of them has a tendency to bend the ship longitudinally or transversely, or to break through any part of her texture, and enquire into those causes which are likely to promote or to obviate the decay of the substances employed.

It is unnecessary to explain here the well-known inequality of the distribution of the weight and pressure, which causes almost all ships to have a tendency to arch or hog, that is, to become convex upwards in the direction of their length. It is possible that there may be cases in which a strain of a very different nature is produced; but in ships of war this tendency appears to be universal. It is, however, very different in degree in the different parts of a ship; and, of course, still more different according to the different modes of distribution of the ballast and stores which may occur in different ships; but in ordinary cases

it will probably be found nearly such as is represented in the calculations from data which were originally furnished by an acute and experienced member of the Navy Board. To this strain another is added, from a cause which, although not very inconsiderable, appears hitherto to have escaped notice; that is, the partial pressure of the water in a longitudinal direction affecting the lower parts of the ship only, and tending to compress and shorten the keel, while it has no immediate action on the upper decks. The pressure thus applied must obviously occasion a curvature, if the angles made with the decks by the timbers are supposed to remain unaltered, while the keel is shortened, in the same manner as any soft and thick substance, pressed at one edge between the fingers, will become concave at the part compressed. This strain, upon the most probable supposition respecting the comparative strength of the upper and lower parts of the ship, must amount to more than one-third as much as the mean value of the former, being equivalent to the effect of a weight of about 1000 tons acting on a lever of one foot in length, while the strain arising from the unequal distribution of the weight and the displacement amounts, where it is greatest (that is, about thirty-seven feet from the head) to 5260, in a seventy-four-gun ship of the usual dimensions; and although the strain is considerably less than this exactly in the middle, and throughout the aftermost half of the length, it is nowhere converted into a tendency to "sag," or to become concave. It must, however, be remembered that, when arching actually takes place from the operation of these forces, it depends upon the comparative strength of the different parts of the ship and their fastenings whether the curvature shall vary more or less from the form which results from the supposition of a uniform resistance throughout the length. An apparent deviation may also arise from the unequal distribution of the weight through the breadth of the ship: thus the keel may actually sag under the step of the main-mast, even when the strain, as here calculated, indicates a contrary tendency with respect to the curvature of the whole ship.

The magnitude of the strain on the different parts of a ship is subjected to very material alterations when she is exposed to the forces of the wind and waves. The effect of the wind is generally compensated by a change of the situation of the actual water line, or line of flotation, so that its amount may be estimated from the temporary or permanent inclination of the ship; and the force of the waves may be more directly calculated from their height and breadth. These two forces can seldom be so applied as to combine their effects in producing a strain of the same kind in their full extent; it will therefore be sufficient for our purpose to determine the probable amount of the force of the waves, which is more materially concerned in effecting the longitudinal curvature than that of the wind. As a fair specimen of the greatest strain that is likely to arise from this cause in any common circumstances, we may consider the case of a series of waves twenty feet in height, and seventy in breadth, the form being such that the curvature of the surface may be nearly proportional to the elevation or depression: a single wave might indeed act more powerfully than a continued series, but such a wave can scarcely ever occur. We shall then find upon calculation that the greatest strain takes place in a seventy-four-gun ship at the distance of about eighteen feet from the midships, amounting to about 10,000 tons at the instant when the ship is in a horizontal position; while in more common cases, when the waves are narrower, the strain will be proportionally smaller and nearer to the extremity. Hence it appears that the strain produced by the action of the waves may very considerably exceed in magnitude the more permanent forces derived from the ordinary distribution of the weight and pressure, being, according to this statement, nearly three times as great; so that when both strains co-operate their sum may be equivalent to about 15,000 tons acting on a lever of one foot, and their difference, in opposite circumstances, to about 5000. There may possibly be cases in which the pressure of the waves produces a still greater effect than this; it may also be observed that the agitation accompanying it tends to make the fastenings give way much more readily than they would do if an equal force were applied less abruptly. At the same time it is not probable that this strain ever becomes so great as to make the former perfectly inconsiderable in comparison with it, especially if we take into account the uninterrupted continuance of its action. It appears therefore to be highly proper that the provision made for counteracting the causes of arching should be greater than for obviating the strain in the contrary direction: for example, if the pieces of timber intended for opposing them were, on account of the nature of their fastenings, or for any other reason, more capable of resisting compression than extension, they should be so placed as to act as shores rather than as ties: although it by no means follows, from the form which the ship assumes after once breaking, that the injury has been occasioned in the first instance by the immediate causes of arching, since, when the fastenings have been loosened by a force of any kind, the ship will naturally give way to the more permanent pressure, which continues to act on her in the state of weakness thus superinduced.

The pressure of the water against the sides of a ship has also a tendency to produce a curvature in a transverse direction, which is greatly increased by the distribution of the weight, the parts near the sides being the heaviest, while the greatest vertical pressure of the water is in the neighbourhood of the keel. This pressure is often transmitted by the stanchions to the beams, so that they are forced upwards in the middle. When they are unsupported, the beams are more generally depressed in the middle, by the weight of the load which they sustain; while the inequality of the pressure of the water co-operates with other causes in promoting the separation of the sides of the ship from the beams of the upper decks. On the other hand, the weight of the main-mast often prevails partially over that of the sides; so that the keel is forced rather downwards than upwards in the immediate neighbourhood of the midships. The tendency to a transverse curvature is observable when a ship rests on her side, in the opening of the joints of the planks aloft, and in their becoming tighter below; although this effect depends less immediately on the absolute extension and compression of the neighbouring parts than on the alteration of the curvature of the timbers in consequence of the pressure. In such a case there is also an obvious strain, tending to produce a lateral curvature: and shores are sometimes employed to prevent its effects, when a ship is 'hove down" on her side. This, indeed, is com-

paratively a rare occurrence; but, when a series of large waves strike a ship obliquely, they must often act in a similar manner with immense force: the elevation on one side may be precisely opposite to the depression on the other, and the strain from this cause can scarcely be less than the vertical strain already calculated; but its effects are less commonly observed, because we have not the same means of ascertaining the weakness which results from it, by the operation of a permanent cause. When a ship posseses a certain degree of flexibility she may, in some measure, elude the violence of this force, by giving way a little for the short interval occupied by the passage of the wave; but it may be suspected that her sailing, in a rough sea, must be impaired by such a temporary change of form.

When a ship takes the ground, she may either give way at once to the stroke of a rock, or rest on a bottom more or less soft, until she is wholly or partially abandoned by the water. In the former case her resistance must depend, in a great measure, on the parts in the immediate neighbourhood of the injury; in the latter it may happen that she may be supported by so large a surface as to be more in danger of parting aloft than of being crippled below. Commonly, however, the floor-timbers are forced in at one end, the first futtucks, which are their immediate continuations, being broken off; and sometimes the opposite ends of the floor-timbers are forced out, especially in large ships without riders, their attachment to the keel remaining unimpaired.

The causes which promote the decay of timber are only so far understood as we are acquainted by experience with their effects. A partial exposure to moisture appears to be by far the most general of these causes: it is well known that total submersion does not accelerate decay; a surface which is kept moist by imperfect contact with another, so that a portion of water is retained between them by capillary attraction, seems always to be the part at which the timbers begin to rot; while both the surfaces completely exposed either to the drier air or to the water, and those which are wedged closely together and press strongly against each other, remain perfectly sound.

We are next to enquire into the comparative advantages of different angular positions of the timbers of a ship, for resisting the forces which have been described; and in particular how far the arrangements which have been proposed by Sir R. Seppings are better calculated for the purpose than the common modes of construction. Sir Robert's experiments show that when two parallel planks have loose pieces interposed, extending perpendicularly from one to the other, they are incomparably weaker, with respect to any transverse force, than when the intermediate pieces are in an oblique direction, so as to constitute a frame which can only be bent as a whole. But it cannot for a moment be imagined that the planks of a ship are connected with the timbers in as loose a manner as these transverse braces, which will scarcely support their own weight, for the purpose of the experiment; and in fact the comparison would have required that the whole space included by the parallelogram should be filled up, in each case, by similar braces, or at least that the two planks should have been firmly united at the loose end to the transverse braces; and it is demonstrable that in this case the same weight would have broken the pins as if one of the planks had been oblique, or as if the planks had remained parallel and had been connected by oblique pieces. Such a result would, however, be far from proving the inutility of the addition of oblique braces to a rectangular frame; for the kind of strength required for any particular purpose is not always determined by the magnitude of the force which would be capable of breaking the substances concerned, although the power of resisting such a force is properly called strength, in the most limited sense of the term: but there are many occasions on which stiffness, or inflexibility, is of material advantage. A coach spring, consisting of ten equal plates, would be rendered ten times as strong if it were united into one mass; and at the same time 100 times as stiff, bending only $\frac{1}{100}$ of an inch with the same weight that would bend it a whole inch in its usual state, although nothing would be gained by the union with respect to the power of resisting a very rapid motion. Now it appears to be extremely difficult to unite a number of parallel planks so firmly together, by pieces crossing them at right angles, as completely to prevent their sliding in any degree over each other; and a diagonal brace of sufficient strength, even if it did not enable the planks to bear a greater strain without giving way, might still be of advantage in many cases, by diminishing the degree in which the whole structure would bend before it broke. The strength of a simple rectangular frame, firmly fixed at one end, is rendered somewhat less than double by perfectly fastening the joints at the other, and the stiffness is nearly quadruple. The comparative security obtained by the addition of the diagonal brace is almost without limit. Supposing any number of planks of equal dimensions to lie simply on each other without any adhesion, and to be firmly fixed at one end, their aggregate strength will be very little greater than that of a single plank of one-sixth part of the common depth or thickness of each, supported by a brace a little stronger in the direction of the diagonal of the whole; and the stiffness of the parallel planks will be as many times less than that of such a frame as there are planks in one-third of the whole series. Thus, if we had twelve planks, six inches deep and one thick, with friction rollers interposed, it is demonstrably true, however surprising, that they would be very little stronger in supporting a weight at the end than a single tie an inch square in its section, assisted by a diagonal brace of equal relative strength; and also that this apparently slight structure would be nearly four times as stiff as the twelve planks, being depressed only one-fourth as much, with a given weight, as the planks with a similar force acting on them.

It is well known that if the planks were firmly united into one mass their strength would be rendered twelve times as great by the union, and their stiffness 144 times. But this is not the greatest resistance of which the materials are capable, even without any extension of their base of support; for if the planks were connected in pairs at half the distance of the whole depth, and allowed to move freely round fastenings perfectly secure, their strength, speaking theoretically, would be greater by one-half than if they formed a compact mass, while their stiffness would be only about one-fourth as great: and an effect nearly similar might be produced if the respective pairs were united by oblique braces, ex-

tending over half the depth of the whole structure, although it would be very difficult, in practice, to make the strength of an arrangement of this kind even equal to that of a compact mass, since the fastenings could never be so perfect as to bring every fibre of each plank into its full action at once, as the theory supposes. If the planks were already united into a compact mass, so as to be incapable of bending, except as a whole, it is of importance to enquire whether any advantage would be gained by the further addition of oblique braces: and it will appear that, if the braces were fixed to the outermost planks of the series only, they would have no manner of effect, either on the strength or on the stiffness, whatever might be their direction; but, if they were sufficiently fastened throughout the extent to each plank with which they come into contact, they would add both to the strength and to the stiffness, very nearly in the same degree as if they were fixed in the direction of the planks, at a distance from each other equal to their shortest actual distance, so as to constitute as many ribs as there are braces in a transverse line. Hence, although there is obviously no economy in such an employment of oblique braces, yet it is by no means true that oblique braces are incapable of adding to the strength of a structure composed of pieces arranged at right angles; the assertion might, however, be very nearly correct in circumstances approaching to those of one of the experiments which have been exhibited for the purpose of illustrating the utility of such braces. On the other hand, the advantage of employing oblique braces must depend, in a great measure, on the degree in which the angular position of the structure would be susceptible of variation without them, since, when properly fastened, they must universally tend to preserve the form unaltered, although they are somewhat less calculated to add to the ultimate strength of the principal tie or shore than if their direction had been longitudinal. To take, for example, the case of a ship's arching, or hogging: if the strength were overcome without any deficiency of stiffness, the upper decks and wales would be elongated, and the butts of the planks aloft parted; while the keel would be somewhat shortened, and the planks near it crippled, so that a ship of 176 feet long and forty feet deep, arching one foot with a uniform curvature, would have the length of the parts aloft, on the level of the quarter-deck, twenty-two inches greater than that of the keel. If, on the contrary, the strength were not overcome, but only the stiffness failed, the angular situation of the parts being altered, and the joints simply becoming loose without parting, the planks would slide on each other, and their square ends would no longer remain in the same vertical line at the ports, while there would be no material alteration in the comparative length of the decks and keel, nor any permanent parting of the butts of the planks. This comparison, therefore, brings the question respecting the general utility of oblique riders into a very narrow compass; and we have only to enquire in what way it is most usual for ships to exhibit symptoms of weakness, in order to decide it. Now it will appear that in cases of arching in general some of the butts of the planks are always found to have parted aloft, at the same time that the angular position of some parts of the structure has as uniformly been more or less altered; and very generally a certain degree of sliding is observable in the planks, at the sides of some of the ports.

It appears, therefore, to be sufficiently established that the principle of employing oblique timbers is a good one, provided it be so applied as to produce no practical inconvenience. We must next enquire whether Sir R. Seppings has introduced it in a manner likely to be effectual, and not liable to any material objections. He places on the sides of a seventy-four gun ship several series of oblique braces, principally between the ports, in the place of the internal planking, making an angle of about twenty-four degrees with the decks, consisting of planks four inches thick and about eleven wide, coaked and bolted to the timbers, and abutting against upright pieces similarly fastened. Now it follows, from what has already been stated, that these pieces have about four-fifths as much effect in co-operating with the neighbouring parts, which act horizontally, as if they had been placed in the same situation with them, even on the supposition that the relative angular situation of the pieces is unalterably fixed; but, for preventing the alteration of this situation, there is no doubt of their being very advantageously arranged, so far as their strength is sufficient; and the existence of a tendency to such an alteration, in a very material degree, appears to be altogether indisputable. Below the gun-deck, the oblique timbers are considerably stronger, although they act under circumstances somewhat less favourable.

Having thus, with the assistance of Dr. Young, fully elucidated Sir Robert Seppings's mode of constructing large vessels, we should be wanting in justice to this improver of our navy did we omit to notice his admirable paper "on a new principle of constructing ships in the mercantile service." And, first, as to the principle on which mercantile ships are at present built, and particularly as regards putting together their ribs or frames, and the arrangement of the materials. In forming the frames or ribs, half of the timbers only are united so as to constitute any part of an arch, every alternate couple being connected together, the intermediate two timbers (termed fillings) being unconnected with each other and merely resting upon the outer planking, instead of giving support to it. Now, it must be very evident that ships so constructed can by no means possess equal strength with those that have the whole of their timbers formed into frames or arches. This loose practice is peculiar to the English merchant-ship builder; and indeed was pursued till very lately even in his majesty's navy, while the preferable system of connecting the ribs was common to other maritime powers.

The principle of uniting the frames, lately introduced in the construction of English ships of war, might, no doubt, be also introduced into the mercantile navy, which would give to the ships in that employ additional strength and increased durability, without adding to the expense of building. But the present mode of joining together the several pieces of the same rib is also highly objectionable. It is done by the introduction of a third piece, technically termed a *chock* or *wedge-piece*, of which pieces the number amounts to upwards of 450 in a seventy-four gun-ship, and not fewer than that number in an Indiaman of 1200 tons. Of these chocks, not one in 100 is ever replaced in the general repair of a ship; for they are not only found

defective, but very generally to have communicated their own decay to the timbers to which they are attached. Besides this, the grain of the rib-pieces being much cut, to give them the curvature required, has a considerable share in weakening the general fabric. That they occasion a great consumption of materials is obvious, as the ends of the two rib-pieces must be cut away, and then be replaced by the chock.

This mode of putting together the frame is also peculiar to the English ship-builder; and Sir Robert says, "I find, from an old work in my possession, dedicated to George I., that the practice was introduced in the construction of English ships about the year 1714: and having heard that so unfriendly to it was the builder (Mr. Naish) of the Royal William that he refused to adopt it, and being desirous of ascertaining the fact, when that ship was taken to pieces at Portsmouth, in 1813, I found that she was built without the wedge-pieces or chocks, to which, in a certain degree, I ascribe her strength and durability, her ribs being by her structure less grain-cut, and for want of chocks less liable to decay in those parts where they are inserted."

Another great defect arising out of the present plan of constructing mercantile ships is that the ends of the lower ribs, or timbers, commonly termed the lower futtocks, are not continued across the keel, so that no support is given in a transverse direction when the ship touches the ground, nor any aid to counteract the constant pressure of the mast. This great sacrifice of *strength* and *safety* is made for no other purpose than that of giving a passage for the water to the pumps.

The floor-timbers, which by this mode of construction are the only timbers that cross the keel, are also weakened for the same purpose. This mode also makes the conveyance of the water very uncertain; for the passage is not unfrequently choked, and the pumps (from its not being practicable to continue them sufficiently down) always leave from six to eight inches of water in the ship; so that these compartments constantly contain a certain quantity of putrid bilge water, offensive and injurious to the health of those on board.

The deficiency of strength causes also an alarming insecurity in the plank of the bottom, as shown at that part termed the garboard strake, which consequently has no other fastening to the general fabric than its connection with the keel: hence it is obvious that, in the event of the keel being disturbed, the garboard strake, from its being attached to it, must share the same fate as the keel, and in that case the loss of the vessel would be inevitable.

To obviate these serious defects is Sir Robert's principal object. By the principle he recommends the component parts of each rib are of shorter length and less curvature, and consequently less grain-cut; they are also more firm and solid by the substitution of coaks, or douels, for chocks or wedge-pieces; and the mode of connecting the lower timbers is better adapted, in the event of a ship grounding, to give support and strength to the fabric.

The plan of connecting the ends of the timbers by circular douels, or coaks, is simply that which has, from time immemorial, been practised to unite the fellies of carriage-wheels; and we learn from Mr. Wood that the same method has been observed in joining together the separate pieces of the shafts of the stone columns in the ruins of Balbec. "Little more of this great edifice (says this author) remains than nine lofty columns supporting their entablature. It is remarkable that the shaft of these columns consists of three pieces most exactly joined together without cement, which is used in no part of the buildings, they being strengthened *with iron pins received into a socket*. How much this method contributed to the strength of the building is remarkably seen in the most entire temple, where a column has fallen against the wall of the cell with such violence as to beat in the stone: it fell against and broke part of the shaft, *while the joinings of the same shaft have not been in the least opened by the shock*.

That the frame of the Talavera, which is built on this principle, is superior in point of strength to a frame constructed on the common system, is fully established by a report from the officers of his majesty's yard at Woolwich to the Navy Board, who directed them to compare the strength of the frames so united with those of the Black Prince, constructed in the usual way with chocks or wedges.

It may be necessary to observe that the frame of the Talavera is composed of small timber, hitherto considered applicable only for the frames of frigates. Sir Robert was prompted to attempt the introduction of the plan on which she is built from there being a surplus store of small timber in the yard, and from a conviction that a well-combined number of small timbers might be made equal, if not superior, both in strength and economy, to the large, overgrown, and frequently grain-cut materials, made use of in constructing the frames of large ships; and the result has shown the correctness of the principle, the adoption of which cannot fail to prove of great national advantage in the application of sloop timber to the building of frigates, and of frigate timber to ships of the line, whenever larger timber cannot be procured. On this principle, also, may frigates and small ships of war, or merchant vessels, be built of straight fir, without the assistance of oak or elm, which were formerly employed to give the necessary curvature to the sides. As it respects the general safety of the ship, it may be proper to state that the timbers uniformly cross the keel; that the frame of the ship is filled so as to form one compact body to the height marked *k*, *plate* III. *figs*. 1 and 2; and that only certain internal streaks of plank, or thick stuff, as it is termed, are introduced, which are those on the joints of the timbers, for the purpose of giving strength where every alternate timber necessarily joins, as shown at *l*, *fig*. 2. All the rest of the inner planking may be omitted, and dunnage battens brought in a perpendicular direction upon the timbers *between* the plank, as shown at *m*, forming regular spaces between each, as is usual at present *upon* the plank, thereby giving an increase of stowage in proportion to the thickness of the plank omitted. Water-courses, as shown by dotted lines at *n*, are to be left in the joints of the timber under the plank, for the purpose of conveying the water to the pumps, which by this plan will reach below the water, instead of being some inches above, as is the case with the present mode above described; consequently, by the proposed system, no stagnant water will remain: and, further, the timber-passage, or water-course, will be one smooth uniform channel, which can be cleared with ease, should it be required, whenever the hold is un-

stowed; whereas, at present, it is accessible in places, and forms compartments of putrid water, without there being any means of removing it.

Passing from the important improvements in the framing of the hull which have originated with Sir Robert Seppings, we have next to examine Captain Schanck's suggestions for a *sliding keel.* The speed of a vessel does not depend so much upon the form of the bow as it does on the depth to which it is immersed in the water. Captain Schanck has stated, very properly, that in the case of a frigate drawing seventeen feet water, and another frigate of the same burden drawing only eleven feet, the latter will have a body of six feet less fluid to divide, opposing only one, two, or three keels, as may be found necessary, to make her hold a good wind, while the former has six feet perpendicular depth of her hull depressed, being about one-third of her real size. It follows, therefore, that she has a body of water to displace, and force herself through, equal to the difference between eleven and seventeen; when it is considered, in addition to this, that the resistance of the fluid rapidly increases in proportion to the depth it is acted against, the disparity is almost incredibly increased. North-country-built vessels, or those in the coal-trade, are a strong proof of this observation. These, in general, draw one-third less water than any other vessels of British construction; yet, when employed as transports, they are generally found to sail as fast as any others; and when going before the wind in ballast, or half loaded, frequently beat the ships belonging to the royal navy. When, however, they are close hauled on a wind they will drop to leeward; but, were they furnished with sliding keels, it is most likely that they would have the advantage over all other vessels. The Dutch, who bestow little pains in making their trading vessels sail, are nevertheless fortunate in this respect; for, when they are light, they sail fast before the wind, owing to their small draught of water. They have also other vessels built almost totally flat, such as pilot boats, yagers for carrying the first herrings to market from Shetland, and pleasure yachts. All these have lee-boards, by the assistance of which they sail as fast as the generality of those which navigate the Northern Seas. These facts are manifestly in favour of flat-floored vessels and sliding keels.

In regard to the sailing trim of a vessel, it is the decided opinion of most scientific men that ships of the larger classes should always be so constructed as to sail on or nearly on an even keel, that is, so that the ship, when trimmed for sailing, should have her keel parallel to the surface of the water; therefore by as much as the effort of the wind on the sails and masts in forcing the ship through the water has a constant tendency to depress the bow, so much should the ship be trimmed by the stern, as that will be found most advantageous both to their sailing and steering.

It is a point too well known to every person conversant in naval architecture to need explanation that the different constructions of vessels will occasion a considerable variance in the quantity which those actually of the same measurement will carry. Ships built sharp forward and aft lose a considerable portion of stowage; while some vessels have the floor so straight throughout the whole of their length that by looking down in the holds of one, and of the other, the difference is easily discernible by the eye. For this reason it is impossible a true measurement ever can be made; and the assertion may be regarded as true that, notwithstanding all which the respectable and learned men of different nations have written on the subject, no certain method will ever be discovered of ascertaining the true capacity of vessels, until they shall be built with a greater resemblance to each other, even in the upper works, as well as in the lower part of the hull. It has frequently been observed by officers, and others who have had occasion to inform themselves practically on the subject, that many ships of the same measurement will not take in nearly the quantity they are estimated to carry; while others, exclusive of the quantity of goods or stores which their constructors allotted to them, can receive a still greater cargo, and carry it with ease. It has been observed, too, that if sharp-built vessels are at any time capable of containing the amount of their calculated tonnage they are never able to carry it with the same ease as vessels of flatter construction, inasmuch as their form forward and aft will inevitably occasion their pitching and shipping water. This inconvenience has been observed to proceed invariably from the cause just assigned; for a sharp-built ship sinks under its cargo so fast that by the time it comes to its bearings it is frequently not nearly loaded. Those which have flat and long floors, on the other hand, sink slowly; and, after having taken in the quantity they measure, will frequently have plenty of room, and remain high out of the water: so that it has happened, not only that an additional cargo has been taken in, but that when two vessels of the same measurement, but of contrary construction, have been laden at the same time, the flat-floored vessel has been enabled to carry what was necessarily rejected by her companion; and, after taking on board the whole of her additional cargo, still continued in the best state of trim. It appears, indeed, to be the opinion of many ingenious naval architects, and of Captain Schanck in particular, that one of the first desiderata in the improvement of the art of ship-building would be to try experiments on the general use of long flat floors, which are supposed by many to promise, under certain regulations, the most extensive advantages.

The only objection that can be advanced against this system is the inaptness of a flat-floored vessel to hold a good wind, a difficulty which may be entirely removed by the adoption of sliding keels, provided they are found, on more critical enquiry, to answer the intended purpose, without occasioning injury to the vessel or material inconvenience to the mariners.

In 1663, Sir William Petty constructed a double ship, or rather a single ship with a double bottom, which was found to sail considerably faster than any of the ships with which it had an opportunity of being tried. Her first voyage was from Dublin to Holyhead; and on her return "she turned into that narrow harbour against wind and tide, among rocks and ships, with such dexterity that many ancient seamen confessed they had never seen the like." This vessel with seventy more was lost in a dreadful tempest.

This subject was again revived by Mr. Gordon, in his *Principles of Naval Architecture,* printed at Aberdeen, anno 1784, where, having delivered his sentiments on the construction of large masts, he says: "These experiments likewise point out to us methods by which two vessels may be laterally connected together, though at a considerable distance

from each other, in a manner sufficiently strong, with very little increase of weight or expense of materials, and without exposing much surface to the action or influence of the wind or the waves, or obstructing their motion in any considerable degree, and consequently without being much opposed by them on that account under any circumstances; and if vessels are judiciously constructed, with a view to such a juncture, it would be no easy matter to enumerate all the advantages that may be obtained by this means." He then enumerates the advantages that double vessels would have over those of the common construction. Soon after double ships were actually built by Mr. Miller, of Dalswinton.

Another plan was proposed by Mr. Gordon to make a ship sail fast, draw little water, and keep a good wind. For this purpose "the bottom," he says, "should be formed quite flat, and the sides made to rise perpendicularly from it, without any curvature; which would not only render her more steady, as being more opposed to the water in rolling, but likewise more convenient for stowage, &c., while the simplicity of the form would contribute greatly to the ease and expedition with which she might be fabricated. Though diminishing the draught of water is, of all others, undoubtedly the most effectual method of augmenting the velocity with which vessels go before the wind, yet, as it proportionally diminishes their hold of the water, it renders them extremely liable to be driven to leeward, and altogether incapable of keeping a good wind. This defect may, however, be remedied in a simple and effectual manner, by proportionally augmenting the depth of keel, or, as so large a keel would be inconvenient on many accounts, proportionally increasing their number; as, in the place of adding a keel eight feet deep to a vessel drawing six feet water, to affix to different parts of her flat bottom, which would be well adapted for receiving them, six different keels of two feet deep at equal distances from each other, with proper intervals between, which will be found equally effectual for preventing these pernicious effects. Four such, indeed, would have answered the purpose as well as the eight-feet keel were it not for the superior pressure or resistance of the lower water."

Thus then it appears that a vessel drawing eight feet water only, keels and all, might be made to keep as good a wind, or be as little liable to be driven to leeward, as the sharpest built vessel of the same length drawing ten or fifteen, if a few more keels were added, at the same time that she would be little more resisted in moving in the line of the keels than a vessel drawing six feet water only. These keels, besides, would strengthen the vessel considerably, would render her more steady and less liable to be overset, and thereby enable her to carry more sail.

This plan has been put into execution by Captain Schanck, with this difference only, that, instead of the keels being fixed as proposed by Mr. Gordon, Captain Schanck constructed them so as to slide down to a certain depth below the bottom or to be drawn up within the ship, as occasion might require.

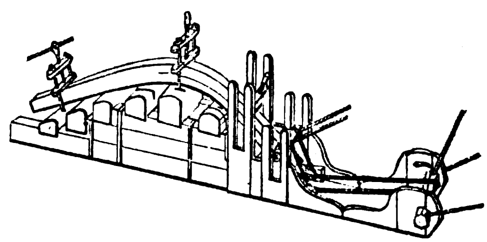
Captain Schanck having communicated his plans to the Navy Board, two vessels were in consequence ordered to be built of thirteen tons each, and similar in dimensions, one on the old construction and the other flat-bottomed, with sliding keels. A comparative trial in presence of the commissioners of the navy was made on the river Thames, each having the same quantity of sail; and although the vessel on the old construction had leeboards, a greater quantity of ballast, and two Thames pilots aboard, yet Captain Schanck's vessel with three sliding keels beat the other vessel, to the astonishment of all present, one-half of the whole distance sailed.

The attention of the reader has hitherto been directed almost exclusively to the form of the vessel: we may next notice the preparation of the timbers.

Mr. Hookey has invented a mode of bending the timbers of a large vessel which promises to be of great practical utility. It is intended principally for the preparing of floor-timbers, futtocks, breast-hooks, long riders, beams, and knees.

In the building of a seventy-four-gun ship on Mr. H.'s plan, a saving will be made of many hundred pounds.

The timber is first sawn down to the middle as far as it is to be bent, as shown by the line in the different timbers, which greatly increases the power of bending it, and permits the one part to slide over the other, so as to lessen the tear of the different parts, which are afterwards secured together by bolts passed through them, and may be still farther stiffened by additional pieces let into them.



The above engraving affords an opportunity of showing the handspikes or levers placed in the holes of the capstans, by the joint action of which the timbers are forced into the requisite curves, to suit which the blocks must be previously arranged, as well as the beams which support them, and which are so managed as to form buttresses to prevent the blocks from shifting their places in the act of bending the timbers, and the whole is securely united together by iron bands.

Having pointed out some important improvements in the construction of vessels, we may now direct our readers' attention to the means of preserving them and their crews from the most fatal of all occurrences, namely, their *foundering* at sea.

Many suggestions have been offered for this purpose, but there appears but one at all fitted for the intended object, and that is founded on the unerring law of nature that whatever is specifically lighter than the quantity of water which its own bulk will displace by immersion will swim, a position exemplified in a variety of ways. For the invention to which we refer the country is indebted to a very distinguished scientific individual named Watson, who has gratuitously devoted himself to the subject from purely philanthropic motives. This important invention consists in the employment of tubes made of copper of a cylindrical form, terminating at each extremity by convex or semi-globular ends; the whole to be hermetically sealed, and to contain, in number and capacity, a bulk or quantity of atmospheric air equal, by its displacement of water, to counterbalance that *extra*

NAVAL ARCHITECTURE.

Fig. 3.

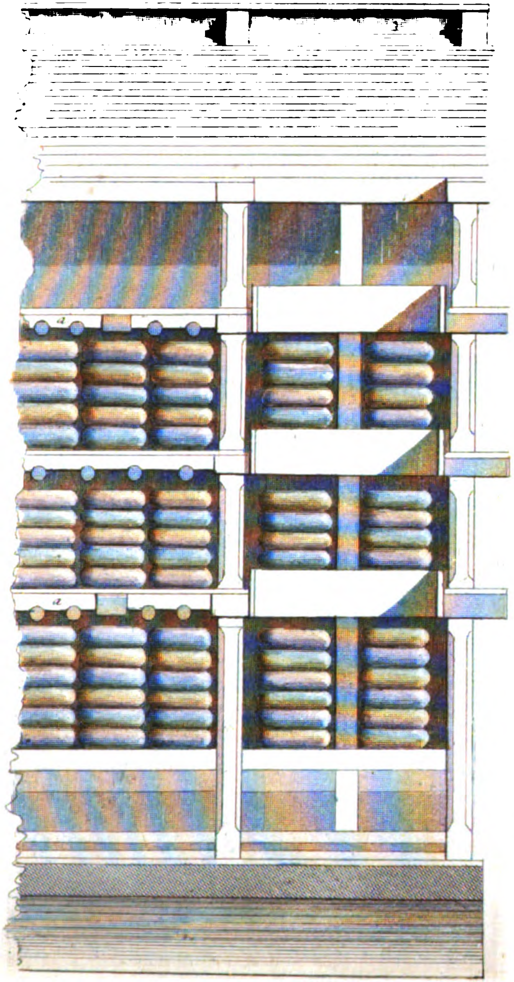
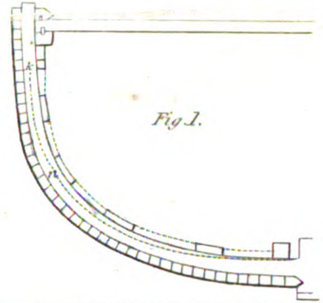


Fig. 1.



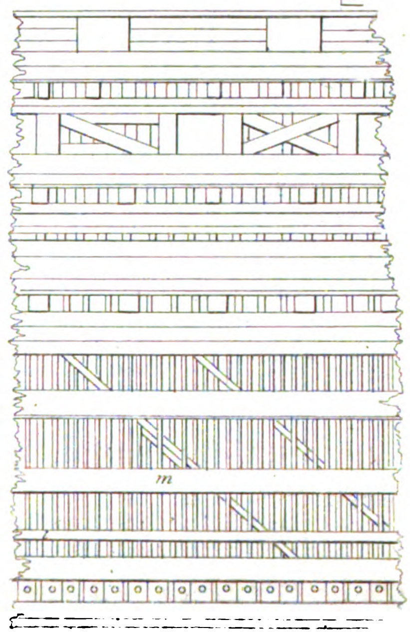
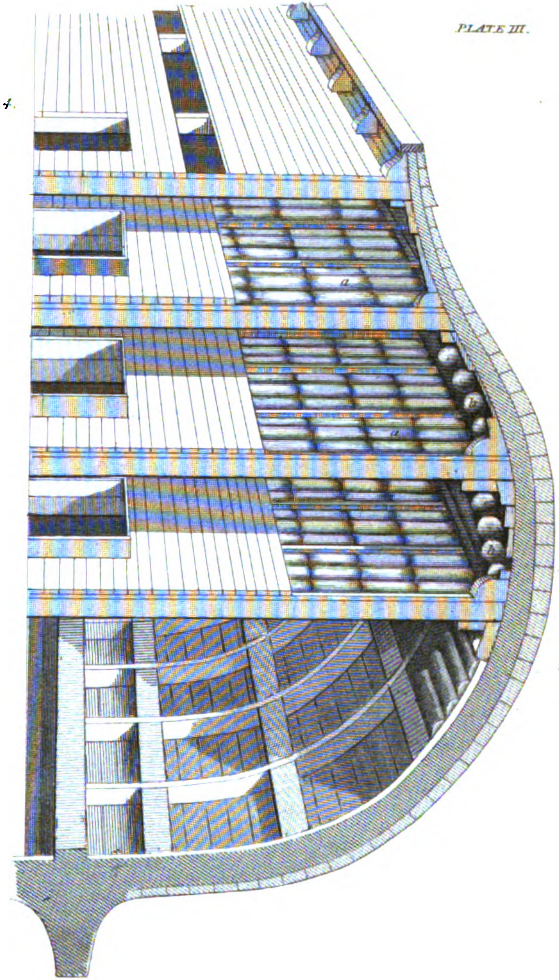


Fig 2

Fig. 4.



London Published by Orr & Smith Paternoster Row Jan. [illegible] 1833

portion of the weight or specific gravity of the ship and her contents which otherwise, in case of leak and the ship filling with water, causes her to sink. It is designed to place the safety-tubes in the spaces between the beams of the decks, also between the timbers or ribs, the shelf-pieces, and the planking, and in all other places below the decks which may be thus occupied without inconvenience.

From presenting a uniform circular surface, the safety-tubes, when immersed, would be perfectly secure against the weight or pressure of the water; and, from spreading their buoyant power equally over the whole range of the ship's several decks, they, in the event of the ship filling, are calculated to preserve her equilibrium or centre of gravity. With regard to that part of the hull of the ship which would, in case of filling from leak, become submerged, it is obvious, from the timber of which it is composed being specifically lighter than water, that the hull itself would not only float without the aid of the tubes, but would support, in that position, a considerable incumbent weight.

Several of the articles on board ships of war under the head of provisions: namely, water, wine, spirits, &c., when immersed, produce no tendency to sink the ship, but on the contrary, from being of less specific gravity than the sea, they afford an assisting buoyancy; and, although some of the remaining provisions are to a certain degree heavier, the greater part, together with the casks (with the exception of the hoops), are lighter than sea water; hence it follows that a very immaterial difference of weight exists between the specific gravity of the provisions and that of the sea, in the event of their submersion. The material weight which the "safety tubes" would have to support in case of the ship filling consists in the various metallic substances used in the building of, and those contained within the ship: namely, the guns, the shot, the chain cables, the pumps, the ballast, the tanks, the gallery apparatus, the bolts, nails, and other iron works, together with the masts, yards, and rigging; but as several of these substances would, in case of the ship filling, become immersed, so would their weight also be reduced to an extent equal to the weight of the bulk or volume of water which they would displace.

These counteractions to buoyancy, which are the inseparable appendages of a ship of war, exist in a very limited degree on board a merchant vessel; and as in most cases a portion of the cargoes of merchant vessels is, upon immersion, known to be specifically lighter than sea water, and as the generality of their cargoes, when immersed, are not very materially heavier than the body or volume of sea water they would displace, it follows that a comparatively small quantity or bulk of atmospheric air would be found requisite to keep vessels of this description afloat, in the event of their filling with water.

Hence, from the aggregate weight or specific gravity of the ship and her contents (whether a ship of war or a merchant vessel) being so materially diminished, when immersed, a sufficient bulk or quantity of atmospheric air, contained within the safety-tubes, the extent of which—reduced by a perfectly correct arithmetical calculation for every size and description of ship—can readily be placed in the parts referred to, so as, in case of the ship filling, to keep her afloat with her main deck above the surface of the sea. So great, indeed, would be the displacement of water, and consequent reduction of specific gravity, that even an eighty-gun ship, when immersed from leak, would not require the application of safety-tubes more than sufficient to support 240 tons of its immense weight.

The application, therefore, of this simple principle to the decks of ships, making them, in case of the ship filling, repose, as it were, upon air-filled tubes, must effectually prevent the possibility of a ship foundering at sea.

With regard to the best mode of applying the tubes, it may be proper to state that they are placed against the timbers and beams which constitute (like the bones with reference to animal life) the whole strength of the ship, and under those strong holds or fastenings which spread over the whole range of the ship, in three distinct divisions, widening where weight accumulates and diminishing where weight decreases: indeed, had the safety-tubes been the first invention of the mind, and had the ship been required to be suited to the reception of the tubes, the general construction of the ship, according to its present build, could scarcely have been better adapted to the object now proposed. Their arrangement will however be better understood by a reference to *plate* III., *figs.* 3 and 4, NAVAL ARCHITECTURE, in which a view is given of the vessel with her safety-tubes. They are represented as placed beneath the decks at *a a*, and a similar series protecting the sides are shown at *b*, thus taking off the strain which would otherwise cause the vessel to "blow up" on her being submerged.

This will, however, be placed in a clearer point of view by the following statement, showing the acting and counteracting effect of weight and buoyancy upon an eighty-gun ship fitted with tubes of this description, supposing the immersion to take place in consequence of a leak.

Weight of the Hull.

	cubic ft.		Tons.	cwt.	qr	lb.	Tns.	cwt.	qrs.	lb.
TIMBER, Oak.	48497	at 55¾ lbs. per ft.	1207	2	0	3				
Fir	4457	34¼	68	2	3	24				
Elm	520	37½	8	14	0	12	1283	19	0	11
	53474									
METAL, Forge work			94	14	0	0				
Copper-bolts and sheathing			49	11	0	0				
Sheathing nails and copper deck ditto			2	18	0	0				
Mixed metal nails			3	19	0	0				
Cast-iron coaks			1	9	0	0				
Lead			6	3	0	0	158	14	0	0
							1442	13	0	11

Weight of the Ship's Contents.

Iron ballast	230	0	0	0				
Iron tanks	40	0	0	0				
Guns and carronades	214	0	0	0				
Powder 22 tons, shot 97	119	0	0	0				
Anchors, 18 tons, chain cables, 20	38	0	0	0				
Hempen cables, 26 tons, gun tackle, 10	36	0	0	0				
Masts and yards	83	0	0	0				
Sails 10 tons, rigging and blocks 64	74	0	0	0				
Boats	10	0	0	0				
Galley	7	0	0	0				
Officers' furniture and stores	8	0	0	0				
Boatswain's stores 9, carpenter's 11, gunner's 4	24	0	0	0				
Ship's company, 700 men, chests and bedding	71	0	0	0				
Proposed safety-tubes	23	0	0	0				
Wine . . . 3267 gals. weighing with casks	13	0	0	0				
Spirits . . 1634 . . . . . . ditto	6	10	0	0				
Vinegar 700 . . . . . . ditto	2	13	1	10				
Water 350 tuns of 250 gals. each	315	0	0	0				
Bread 78,400 lbs. in 700 bags	35	6	1	0				
Beef 3675 pieces of 8 lbs. each, with casks	16	2	0	25				
Pork 7350 ditto 4 lbs. ditto	16	2	0	25				
Carried over					1381	14	0	4

	Tons. cwt. qr. lb.	Tns. cwt. qr. lb.
Brought over—		
Weight of the hull - -		1442 14 0 11
Weight of ship's contents -	1381 14 0 4	
Flour 22050 lbs. in casks weighing 2955 lbs - - - - - -	11 3 1 1	
Suet 1838 lbs. ditto 667 lbs.	1 2 1 13	
Raisins 3675 lbs. ditto 497 -	1 17 0 26	
Peas 306 bushels ditto 2760 -	10 8 1 0	
Oatmeal 88 bushels ditto 495 -	1 17 0 19	
Sugar 7350 lbs. ditto 1456 -	3 18 2 14	
Cocoa 4900 lbs. ditto 990 -	2 12 2 10	
Tea 1225 lbs. in chests. do. 1078 -	1 0 2 7	
Preserved Meats - - - - -	0 12 2 0	
Tobacco 5600 lbs. in csks. do. 1680 lbs.	3 5 0 0	
Soap 2800 lbs. candles 1502 lbs. in boxes weighing 717 lbs. - -	2 4 3 7	
Coals 69 tons wood 6 t. 13 cwt. 1 qr. 10 lbs. - - - - - - - -	75 13 1 10	
Water casks 156 tuns, weighing empty - - - - - - -	26 9 1 4	
		1523 19 0 3
Total weight of the ship and her contents -		2966 12 0 14

Displacement of Water, upon Immersion.

	Cubic Feet.	
Timber in the build of the ship's hull	53474	
Deduct for timber above the level of the main deck remaining unimmersed, consequently a dead weight, say one-twelfth - -	4456	
	49018	

	Tons. cwt. qr. lb.	
which 49018 cubic feet of timber, when immersed, will displace a bulk of sea water equal, at 64¾ lbs. per cubic foot, to - - - -	1416 18 1 26	
Metal, 100 tons, in the build of the ship, displacing 494 cubic feet of sea water, equal to - - - -	14 5 2 10	
Space below the main deck, occupied by divers articles, which upon the hull's immersion from leak would displace 34,000 cubic feet of sea water, equal to - -	982 16 1 0	
The ship's supply of fresh water rendered inoperative upon the hull's immersion from leak -	315 0 0 0	
		2729 0 1 8
Super-specific gravity, or excess weight - - - - - - - - - -		237 11 3 6

Counteraction of the Excess Weight, by means of the Safety-tubes.

Safety-tubes, containing 10,000 cubic feet of atmospheric air, hermetically sealed, displacing the like quantity of sea water upon the hull's immersion from leak, equal, at 64¾ lbs. per cubic foot, to - - - - -	289 1 1 0
Excess of buoyancy, which may be considerably augmented by instantly cutting away the masts, sails, and rigging, and by throwing overboard the upper deck guns, &c. - - - - - - - - - -	51 9 1 22

That the ship's equilibrium or centre of gravity, in case of immersion from leak, cannot be disturbed, must be apparent when it is considered that all the principal weights, viz. ballast, &c., would continue in the same part of the ship in which they are now put to keep her upright and her keel sufficiently low; and that the only difference is that the air is to be confined within the safety-tubes, in order to support the ship afloat in case of immersion, whilst in her ordinary state of sailing that same element, which is actually the main cause of her present flotation, freely circulates in the whole interior of the ship.

In further support of the impossibility of the ship's centre of gravity being destroyed, it should be observed that the safety-tubes, which are thus wholly above the greater mass of dense substances, rise in an even line with the particular weights attached to each of the several decks, which consequently have no material preponderating weight above them, except the upper-deck guns, with the masts, yards, and rigging, most of which, in the hour of storm, or on the ship springing a severe leak, would in all probability be instantly thrown overboard, and thereby, be it observed, a considerable elevation of the ship from her state of immersion would instantly ensue. Again, upon the ship, in the state of immersion from leak, lurching either to the starboard or the larboard, it is obvious that whilst the tubes on the upward side of the ship would be in part above the surface of the water, and to a certain extent go out of action, the tubes inclined with the ship's side downwards, from the increased bulk of water above them, would come into more powerful operation, and produce a counteraction tending to make the ship instantly right herself.

For the purpose of affording a clear view of the value of the tubes as applied to merchant ships, we add the following statements, with reference to two of their principal classes, the accuracy of which may be relied on.

EAST INDIAMAN OF 1300 TONS MEASUREMENT.

Statement showing the acting and counteracting effect of the weight of this ship, when immersed from leak, and fitted with the proposed safety-tubes.

Weight of the Hull.

	Cubic ft.		Tons. cwt. qr. lb.	Tns. cwt. qr. lb.
TIMBER, Oak.	36603	at 55¾ lbs. per ft.	910 19 3 5	
Fir. .	4075	34¾ - -	63 4 1 10	
Elm.	1911	37½ - -	31 19 3 10	
	42589			1006 3 3 25
METAL, Forge work - - - -			74 4 2 23	
Copper bolts, nails, &c. -			27 10 0 27	
Copper sheathing and sheathing nails - - - - -			12 9 2 6	
Lead, about - - - -			5 0 0 0	
				119 4 2 0
				1125 8 1 25

Weight of the Ship's Contents.

Ballast, guns, shot, and anchors -	263 0 0 0	
Masts, yards, rigging, booms, spars, sails, &c. - - - - - -	207 0 0 0	
Shipwrights' and other stores - -	9 0 0 0	
Provisions - - - - - - -	68 0 0 0	
Water - - - - - - -	90 0 0 0	
Wood and coals - - - - -	90 0 0 0	
Ship's company, chests, and bedding	13 0 0 0	
CARGO, Lead, copper, and iron -	300 0 0 0	
CARGO, Private trade - - -	100 0 0 0	
CARGO, Broad cloth, 2600 bales -	470 0 0 0	
Proposed safety-tubes - - - -	14 0 0 0	
		1624 0 0 0
Total weight of the ship and her contents -		2749 8 1 25

Displacement of Water, upon Immersion.

	Cubic Feet.	
Timber in the build of the ship's hull	42589	
Deduct for timber above the level of the main deck remaining unimmersed, consequently a dead weight, say one-twentieth - - - -	2129	
	40460	

	Tons. cwt qr. lb.	
which 40460 cubic feet of timber, when immersed, will displace a bulk of sea water equal, at 64¾ lbs. per cubic foot, to - - - - - -	1169 10 3 21	
Space below the main deck, occupied by the cargo, &c., which, upon the hull's immersion from leak, would displace 48000 cubic feet of sea water, equal to - - - -	1387 10 0 0	
The ship's supply of fresh water rendered inoperative upon the hull's immersion from leak - - -	90 0 0 0	
		2647 0 3 21
Super-specific gravity, or excess weight - -		102 7 2 4

Counteraction of the Excess Weight, by means of the Safety-tubes.

	Tons. cwt. qr. lb.
Safety-tubes, containing 6000 cubic feet of atmospheric air, hermetically sealed, displacing the like quantity of sea water upon the hull's immersion from leak, equal, at $64\frac{1}{4}$ lbs. per cubic foot, to - - - - - - - -	161 10 0 20
Excess of buoyancy, which may be considerably augmented by instantly cutting away the masts, sails, and rigging, and throwing overboard the guns, &c. - - - - - - - - - -	68 3 2 16

The preceding statement, comprising the particulars of an actual cargo, demonstrates the successful result of the calculation with reference to an East Indiaman, laden with as large a portion of dense weight as, upon almost any occasion, she would be likely to carry.

The whole displacement of water produced by this ship, when drawing twenty-two feet, would be 96,458 cubic feet.

The total area of space below the main-deck is about 114,900 cubic feet, of which about 25,000 become occupied by various substances appertaining to her, leaving a clear area of about 89,900 cubic feet for the reception of cargo, and for general purposes, viz.—

	Cubic Feet.
In the hold for cargo	64,613
Under the middle deck, for cargo and general purposes	15,298
Under the upper deck, for general purposes	9,975
	89,886

If every minute portion of the hold be, as generally stated, filled with cargo, it is calculated that, upon the immersion of a ship of this measurement from leak, 48,000 cubic feet of water (a proportion of only three-fourths of the space in the hold) would become displaced by such cargo.

The following spaces, independently of others that may be found, without any material encroachment upon the ship's room, may be appropriated for the reception of the safety-tubes, viz.—

	Cubic Feet.
Between the timbers	2800
Between the beams of the lower deck .	2091
Between the beams of the middle deck	1958
Between the beams of the upper deck	1360
	8209

Of these 8209 cubic feet, it is calculated that 6000, occupied by safety-tubes, will be sufficient to counteract the effect of the excess of weight of the ship, upon her immersion from leak.

The outlay for the supply of these 6000 cubic feet of safety-tubes is estimated at 2400*l.*, the interest upon which sum, with a charge of one per cent. for wear and tear of the copper, would be 144*l.*; and calculating 33,000*l.* as the cost of the ship when completely fitted for sea, and estimating the value of the ship and her cargo together to be 100,000*l.*, the real charge resulting from the adaptation of the plan to this class of ships would not exceed three shillings per cent. per annum upon the property thus secured from foundering. We need hardly add that this sum is but as dust in the balance compared with the advantages to be derived from the general adoption of this plan on the score of humanity.

WEST INDIAMAN OF 450 TONS MEASUREMENT.

Statement showing the acting and counteracting effect of the weight of this ship, when immersed from leak, and fitted with the safety-tubes.

Weight of the Hull.

	Tons. cwt. qr. lb.	Tons. cwt. qr. lb.
TIMBER, Oak. 12716 cubic ft. at $55\frac{3}{4}$ lbs. per ft.	316 9 2 13	
Fir. . 1032 at $34\frac{3}{4}$ - -	16 0 0 22	
Elm. 459 at $37\frac{1}{2}$ - -	7 13 2 20	
14207		340 3 1 27
METAL, Forge work - - - - -	17 1 1 8	
Copper bolts, nails, &c. -	3 6 2 20	
Copper sheathing and sheathing nails - - - - -	6 0 1 14	
Lead, about - - - - -	2 0 0 0	
		28 8 1 14
		368 11 3 13
Weight of masts, sails, rigging, anchors, ballast, stores, &c., including the cargo, to the extent of her burden - - - - - - -		832 0 0 0
Total weight of the ship and her contents -		1200 11 3 13

Displacement of Water, upon Immersion.

	Cubic Feet.		
Timber in the build of the ship's hull	14207		
Deduct for timber above the level of the main deck remaining unimmersed, consequently a dead weight, say one-fortieth - - - - -	355		
	13852		
		Tons. cwt. qr. lb.	
which 13,852 cubic feet of timber, when immersed, will displace a bulk of sea water equal, at $64\frac{1}{4}$ lbs. per cubic foot, to - - - - -		400 8 2 10	
Space below the main deck occupied by the cargo, &c., which, upon immersion from leak, will displace 26,500 cubic feet of sea water, or		766 0 1 7	
			1166 8 3 17
Super-specific gravity, or excess weight - - - - - - - - - -			34 2 3 24

Counteraction of the Excess Weight, by means of the Safety-tubes.

Safety-tubes, containing 1700 cubic feet of atmospheric air, hermetically sealed, displacing the like quantity of sea water, upon the hull's immersion from leak, equal, at $64\frac{1}{4}$ lbs. per cubic foot, to - - - - - - -	49 2 3 7
Excess of buoyancy, which may be considerably augmented by instantly cutting away the masts, sails, and rigging, and throwing overboard sundry weighty substances - - - -	14 19 3 11

In the foregoing statement no particulars of cargo are given, but in place thereof the total weight which a vessel of this tonnage could carry.

The whole displacement of water produced by this ship, when drawing eighteen feet six inches, would be 41,996 cubic feet.

The total area of space below the main-deck of a merchant vessel of this measurement is about 45,500 cubic feet, of which about 6700 are occupied by various substances appertaining to her, leaving a clear area of about 38,800 cubic feet for the reception of cargo, and for general purposes, viz—

	Cubic Feet.
In the hold for cargo . . .	32,986
Between the upper and the under deck, for general purposes . . .	5,799
	38,785

Assuming the hold to be filled with cargo, both upon the outward and homeward voyage, the for-

mer composed of a variety of articles, of comparatively small specific gravity, the latter of rum, cotton, sugar, or coffee, two of which articles afford an actual buoyancy, it is calculated there would be a displacement equal to 26,500 cubic feet of sea-water.

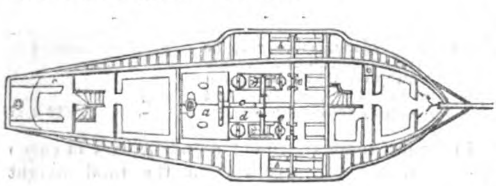
The spaces, independently of others which may be readily found, for the reception of the safety-tubes, are as follow, viz.—

	Cubic Feet.
Between the timbers	1400
Between the lower deck beams . .	400
Between the upper deck beams .	300
	2100

Of these 2100 cubic feet it is computed that 1700 occupied by safety-tubes will suffice to counteract the effect of the excess weight of the ship upon her immersion from leak.

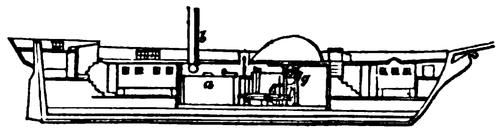
The outlay for the supply of these 1700 cubic feet of safety-tubes is estimated at 680*l.*, the interest upon which sum, with a charge of one per cent. for wear and tear of the copper, would be 40*l.* 16*s.*; and calculating 15,000*l.* as the cost of the ship when completely equipped for sea, and estimating the value of the ship and her cargo together to be 50,000*l.*, the real charge to this class of ships would not exceed twenty-pence per cent. per annum upon the property thus secured from foundering.

In concluding this article, it may be advisable to furnish our readers with a general view of the arrangement of a vessel intended for the purpose of steam navigation. Great strength is one of the first requisites in this species of naval architecture. When steam-power was first employed on the Thames the vessels required to be rebuilt every third year. Now, however, thanks to the improvements that have been effected by a partial application of the diagonal bracing, and the diminished strain of the engines by which they are propelled, they last nearly as long as an ordinary sailing vessel. The accompanying diagram shows the general arrangement of the engines, boiler, &c.



The boilers at *a* should at all times be united by a common steam-pipe, so that in the event of one giving way the other may be made to furnish a supply of steam to both engines. This would of course be with diminished power, but yet it would effectually prevent the serious accidents which have arisen from one paddle-wheel being in operation and the other stationary. The main cylinder of one engine is shown at *d*, and the air-pump at *e*. The paddles are represented at *h h*, the boxes or cases being removed from above. Metal fastenings might be employed with great advantage in the construction of steam-boats, especially between the paddle-boxes and the frame of the engine.

In the best steam-boats the steering-capstan is placed in the bow instead of the stern, and the rudder is acted on by two strong ropes which run the entire length of the vessel. This great improvement was we believe, suggested by Captain Hall.



In the above section the boiler *a* is shown with its chimney *b*. The inner-works of the vessel must be arranged so as to permit of a perfect non-conducting substance being carried round the furnace: pounded charcoal mixed with salt and sand is a good material for the purpose. The engine-room is shown at *g*. If attention be paid to the matter of ventilation when the vessel is first built, there will be no difficulty in carrying on a forced ventilation from the bow to the stern. This is a desideratum in any vessel, but is more particularly so in the heated atmosphere which completely pervades a steam-boat. The best modes of purifying the air in larger ships will be illustrated under VENTILATION. (See also SHIPS.)

NAVIGATION; the art of ascertaining the geographical position of a ship, and directing her course.—Horace has well said that his heart must needs have been bound with oak and triple brass who first committed his frail bark to the tempestuous sea. Nothing, indeed, conveys a higher idea of human daring than the boldness with which man rushes forth to encounter the elements: nothing speaks louder in praise of human ingenuity than that wonderful art by which he is enabled to forsake the land, retiring from it until it fades from the horizon, and nothing visible remains but the hollow heavens above and a trackless waste below; driven from his course by adverse winds, yet by dint of perseverance wearying out the elements, and at length arriving, with unerring certainty, at the expected haven.

If, however, the daring and ingenuity of the navigator deserve our admiration, the result of his efforts will not appear unworthy of the means. It is to the exercise of his wonderful art that we are indebted for the improvement of our condition, which arises from the exchange of the superfluity of one country for that of another, the whole world being penetrated, and every clime made tributary to every other, until the globe is reduced to one common country. Above all, to navigation are we indebted for that higher and nobler advantage, the interchange of sense and sentiment, which makes wisdom common to the world, and urges man onward in the race of improvement. Yet it has not always been so. Time was when the canoe or the raft constituted the only ship of the sailor, and when the narrow precincts of a lake or river set bounds to his roving disposition, and confined him within view of familiar objects. Advancing a step further, we find him venturing from headland to headland, or from island to island, with a view of gratifying his curiosity, or bettering his condition, until a gale, driving him to some unknown coast, increases at once his knowledge and hardidood. Meantime, his bark adapts itself to nobler functions, enlarges in size, and improves in form: the rudder is added, the mast is better sustained, and the sail receives a more favourable application. And thus the art by which the ship is made, and that by

which it is conducted, advanced with equal steps. Deprived of the aid of surrounding objects, the land withdrawn from view, and nothing within the verge of the horizon but a waste of trackless water, the mariner casts his eyes in despair to the overhanging heavens. Aid is granted to his prayers: the constellations assist him in his course: among many revolving stars, he finds one stedfast, and makes it his perpetual guide.

Such do we find the actual state of navigation among the savage tribes of our own day; and such was also the progress of the art among the earliest nations that improved it. Not the least of the improvements which we have made in this art is that simplification in practice by which it is rendered available with little study and capacity. Anomalous as it may seem, yet it is true that more study, more experience, and laboriously acquired information, were necessary to form an Acestes, or a Palinurus, than are now required to furnish forth a La Perouse or a Parry. The master, or pilot, of ancient times, who had command of the sailors, and directed all the evolutions, was not merely required to know whatever related to the management of the sails, the oars, and the rudder: it was necessary for him to be familiar with all the ports that lay in the track of his navigation, the landmarks by which they were designated, and all the rocks, quicksands, and dangers of the intervening deep: he must know the course of the winds, and the indications which preceded them; also the movements of the celestial bodies, not merely for the purpose of directing his course by them, but to understand the winds and weather which some of them, as Arcturus and the Dog-star, were believed to portend. Moreover, he had to be skilled in reading the various omens which were gathered from the sighing of the wind in the trees, the murmurs of the waters and their dash upon the shore, the flight of birds, and the gambols of the fishes. A voyage was, in those days, a momentous and awful undertaking. When the time arrived for the sailing of a ship or fleet, the masts were raised, the sails bent, and all made ready with solemnity, and great parade of preparation. If, as was most usual, the ships were hauled up on the shore, the mariners placed their shoulders at the sterns, and, at the word of command, pushed their bows forward into the sea, leaping aboard when they floated. Levers were used to move the heavier vessels, and, in later times, the *helix* (probably jack-screw), which Archimedes had invented for that purpose.

Before putting to sea, the gods were ever solemnly invoked, and propitiated by numerous sacrifices; thus we find all Homer's heroes sacrificing to the gods before they undertake a voyage; and Virgil's Anchises venturing forth only after having devoted a bull to Neptune and another to Apollo. Nor did the voyagers alone supplicate protection: the crowds of friends and countrymen, who thronged the shore, joined fervently in prayer for their deliverance from danger, and, like the Venusian poet, commended their departing friends to the presiding deities of the winds and waves. All omens were carefully regarded; the entrails of the sacrifices examined, with every possible prognostic of good or evil; and a very small matter, the perching of swallows on the ships, or an accidental sneeze to the left, was enough to delay departure. As this, however, never took place without the most favourable auspices, it was always joyful. The ships were adorned with streamers and garlands of flowers; and, when the signal was given from the admiral's ship, by sound of trumpet, a shout of rejoicing rang through the fleet, sent back by the responding blessings of the friends that remained. After advancing a short space, doves, which the mariners had brought from their homes, were released, and their safe arrival—not unfrequently charged with the last adieu of a departing lover—was considered auspicious of the return of the fleet. The Admiral led the van, conspicuous by his painted sails and streamers, and opened a path in which many followed. In moderate weather, the ships often sailed side by side; but, as the wind freshened, and the sea grew rough, the order became more open, to avoid contact. At all times, they kept close to the land, following the indentations of the coast. When night approached, it was customary to anchor, or else to beach the vessels, that the crews might repose, each rower sleeping on his bench, ready to renew his labours with the returning sun. If the amenity of the weather, the friendly aid of the moon, or the open nature of the navigation, admitted of sailing during the night, the plummet or the sounding-pole directed their course, or it was shaped, as by day, from headland to headland. If the land was not visible, the known direction of the wind continued, with the aid of the stars, to guide them Cynosura was the favourite star of the Phœnicians; the Greeks abandoned themselves to the direction of Helice.

Having escaped the multiplied dangers of such a navigation, and having accomplished their object, the ships returned home with songs and rejoicings. If they were to be stranded the sterns were turned towards the shore, and the vessels forced backwards upon it with the oars, until the crew landing drew them beyond the reach of the surf. Sometimes they were taken into the beautiful moles or artificial harbours which the ancients constructed with great labour and ingenuity within the natural ones. These were in the shape of crabs' claws or horns, the ends, which formed the entrance, so overlapping as to exclude the swell of the sea. Castles defended their approach; and a light-tower, placed at the entrance, guided those who sailed along the coast, or desired to enter by night: this was called *Pharos*, from the island at the mouth of the Nile where the first tower had been erected. Here the vessels were not hauled up, but simply fastened to the rings or pillars provided for the purpose, while at the inner port were docks and stores for building and repairing. In this port, too, were temples devoted to the gods, and especially to the patron of the place, where propitiatory sacrifices were made, and vows fulfilled or recorded; here, too, were numerous taverns and places of more licentious gratification. Whether, however, they stranded their vessels on the beach, or moored them in the harbour, the mariners, before repairing to these resorts, fulfilled the vows made before departure or in seasons of peril, offered thanks to Neptune and sacrifices to Jupiter, for having granted them a release from the durance of their ships. Upon those who had escaped shipwreck gratitude was more deeply incumbent. In addition to other sacrifices, proportioned to their means, they usually offered the garment in which they were saved, together with a picture descriptive of the disaster. If nothing else remained to them, the hair was shorn from the head and consecrated to

the tutelar deity; hence offering the hair was the last vow of the distressed mariner.

There is certainly much that is beautiful in these simple acts of piety; but, except in some Catholic countries of the Mediterranean, where pictures representing the rescue, and garments, are still hung before the shrine of an invoked intercessor, and where processions are still made after escape from shipwreck, none of these touching customs now remain. What can be more beautiful than the grateful sense of divine interference with which Columbus and his followers hastened to fulfil their vows after their safe return to Palos? Such piety, if it availed not to avert present danger, at least served to inspire confidence to meet it; and, when past, the gratitude which it occasioned must have tended at once to refine the sentiments and ennoble the heart.

Imperfect as were the means and knowledge of the ancients in this noble art, yet the Carthaginians, who superadded the greatest commercial enterprize to the greatest skill which had yet been attained, achieved results which may even now be esteemed brilliant. They made the whole of the old world tributary to their city. Not contented with exploring every nook and corner of the Mediterranean, they left behind the ocean which had hitherto almost entirely bounded the excursions of their predecessors, visited the Atlantic coasts of Europe and the British isles, and, pursuing the grand idea which afterwards led the Portuguese to India, discovered a vast extent of the western coast of Africa. Pliny even states that Hanno completed its circumnavigation and returned home by the Red Sea.

Had not Carthage prematurely fallen beneath the rivalry of a nation braver and more barbarous, Vasco da Gama might have had to seek laurels elsewhere than by sailing first to India, and even Columbus been spared the most brilliant and enviable of all the achievements of navigation, the discovery of the New World. The art of navigation gained nothing after the fall of Carthage; and the invasion of the northern barbarians effectually extinguished the few gleams of science which had survived her destruction. Every thing remained stationary for centuries, until the returning day of civilization began once more to dawn upon the world. It was not until the close of the twelfth century that man became sensible of the existence of the most singular property which an ill-wise and all-beneficent Creator has provided to be his guide upon the deep; nor until a still later period that the genius to improve it—the gift of the same good Being—at length rendered it available to so noble a purpose. We allude to the polarity of the magnet and the invention of the mariner's compass. The property of that mysterious mineral to attract iron was early known to the Greeks and Chinese; but the far more singular one of assuming a particular direction was not even suspected. Pliny himself, who records every thing known or fancied in his time concerning the magnet, makes no allusion to its polarity. The first accounts of this mention it as known in the twelfth century, and as being sometimes used by mariners to ascertain their course. While the heroes of the remotest times come down to us, not only with an accurate account of battles fought and thousands slain, but with a minute detail of their private lives and most insignificant peculiarities, posterity is at a loss to know whom to bless for a recent discovery, of all others the most useful in its results, the most important in its influence upon the destinies of man. The effects of this discovery upon navigation were not, however, immediate; for the mariner, as much as any one the slave of habit, could not at once appreciate and confide in the excellence of his new guide. This is the only excuse for the uncertainty which hangs about the identity of the discoverer. The experience of half a century, however, showed the value of this new assistant.

Navigation now assumed a bolder character. Prince Henry of Portugal, son of King John, having gained a brilliant reputation in a war with the Moors, turned from these fierce pursuits to the more congenial one of science. Retiring from court, he established himself in a retreat upon the promontory of St. Vincent, and, calling round him astronomers and mathematicians from every nation, he collected and systematized all the science of the day. Nor were his researches of a merely speculative character; they were directed to enlighten the field of discovery in which he was engaged in search of a nearer route to India, and which, though he attained not the grand object of his ambition, repaid him well by the inferior discoveries to which it led. It was to aid these enterprizes that he caused charts to be drawn, which, though they involved the monstrous supposition of the earth's being an extended plane, were of no inconsiderable use to the navigator, as they brought together whatever was known of the relative position of the different points of the earth, and enabled him to see at a single glance, as in a picture, not only the direction of the port which he desired to visit, but also the various coasts, rocks, and quicksands, to be avoided in the way. He also invented the astrolabe, which at that period was simply a quadrantal arch, graduated at the rim into degrees and half degrees. One edge of the instrument was directed towards the heavenly body whose altitude it was desired to measure, and a plummet suspended from the centre was made to mark the angle of elevation. This was used at first to discover the latitude from the elevation of the pole star; for as that star is in the horizon when viewed from the equator, and rises gradually in approaching the pole, so that it would at length become vertical, it follows that the elevation is always equal to the observer's distance from the equator, which is the latitude. The error resulting from the star's not being exactly polar was of little note in those primitive days of the art. Soon after, by causing tables of the sun's declination to be computed, Prince Henry enabled the mariner to deduce his latitude more correctly from the meridian altitude of that star.

All these improvements, however, though they added much to what was already known, left the art in its infancy. Columbus was the most accurate navigator of his day; still we find him often making an error of so many degrees in his latitude that the mistake of an equal number of minutes would not be excused in a modern navigator. To mention one of many instances, he places San Salvador three degrees north of its true position. But, if Columbus made his discovery with such imperfect means, the greater was his merit: to him belongs the credit by pushing boldly forth amid the uncertainties of the ocean of forcing navigation as well as ship-building to provide against new difficulties, and march rapidly onwards in the career of improvement. From the moment that the hitherto hidden mysteries of the ocean were thus solved, we find improvements and inventions multi-

plying in rapid succession: first, the log is introduced to measure the ship's rate of sailing. Nunes, a Portuguese mathematician, next shows that the shortest distance from place to place upon the surface of the globe must always be along a great circle of the sphere; he also proves the fallacy of the plane chart. Gerard Mercator, a Fleming, nexts suggests the idea of extending the meridian lines on the plane chart, in receding from the equator, in a ratio equal to the error occasioned by supposing the meridians parallel, instead of gradually converging as they do towards the poles. By this means the advantage of a plane surface was retained without the error of the old chart or the inconvenience and imperfection of the globular projection.

Wright, an Englishman, improving the suggestion of Mercator, calculates a table of meridional parts, increasing the length of the arches of meridians in due proportion towards the poles, and furnishes, thereby, data to determine, in any latitude, the difference of any longitude from the point of departure, or the distance sailed east or west. At the same time, lord Napier's invention of logarithms wonderfully diminishes the labour of calculation, enabling the mathematician, by their help, to substitute for the tedious operation of multiplication and division the simpler ones of addition and subtraction. Now, too, Gunter presents the seaman with his admirable scale, containing the logarithmic lines, by aid of which and a pair of dividers, all the problems of geometry are easily and accurately performed. The circumference of the earth is ascertained by measuring a given portion of its arch; and, the length of a degree being known, the log-line is marked accordingly. The quadrant, or rather octant, is invented, and measures the altitude of the heavenly bodies to the nearest minute, undisturbed like the astrolabe by the motion of the ship. The sextant and circle still improve upon the octant and each other. And now the tables of the moon's motions, invented by Meyer, with a view to ascertain the longitude, are improved by Maskelyne. The idea of finding the longitude by the watch had been early suggested as an important use of that admirable machine; but it continued too imperfect until the last century, when the munificent rewards offered by our government so stimulated mechanical ingenuity that it has at last become admirably adapted to this important purpose.

To those who are ignorant of the means by which men are enabled to trace their way over a trackless deep, and to whom the whole art is a mystery, it may be interesting to learn how seamen, and often very ignorant ones, are able successfully to practise it. We shall, therefore, in conclusion, briefly explain the actual practice of navigation: and, first, it may be necessary to premise, that, in order to determine and designate positions on the surface of the globe, latitude and longitude have been invented. Nor is this system entirely arbitrary, since nature herself furnishes the data. We have the poles, determined points of that axis round which the earth performs its daily revolutions: equidistant from these poles, and midway between them, nature aids us to conceive a line called the *equator*, and about which, by the motion of the earth in its orbit, the sun seems to perform an equal movement, accomplishing the beautiful scheme of the seasons by an annual excursion on either side.

What idea more obvious, and, at the same time, more beautiful and complete, than that of measuring latitude from the equator towards the poles, upon meridional lines perpendicular to it, and formed upon the surface of the earth by planes of its axis? But the latitude, though it indicates the distance from the equator, does not alone determine the position; for the same latitude may correspond to an infinity of places, except only a latitude of ninety degrees: hence, then, the necessity of longitude, measured round the world upon the equator, and small circles parallel to it; for, crossing each other at right angles, the same latitude and longitude can only concur at one given point. Latitude and longitude are measured in degrees, minutes, and seconds; the first, from the equator to the poles, a quadrant of ninety degrees; the second, from the first meridian east and west, a semicircle, or 180 degrees, and meeting at the antipodes.

Let us now show the means by which the mariner guides his bark across the ocean, and is able, at all times, to determine his progress and position. The most important instrument used by the navigator is the compass. Having in the compass an instrument for directing our course, we next seek the means of ascertaining the distance run. This we find in the log. The log is a long cord, having a piece of wood attached to one end. This is of a quadrangular form, and being slung at the corners with line, and loaded at the circumference, when thrown overboard it remains erect and stationary, and drags the line off as fast as the ship passes through the water. The line is divided into knots and half knots, representing miles and half miles, or minutes of a degree, to which they bear the same proportion as the log-glass does to an hour. Thus the log-glass being filled with sand, to run through in thirty seconds, the length of a knot must be fifty-one feet, the first being the same proportion of an hour that the last is of a mile. As, however, the log is found to come home a little in the effort to draw the line out, it is customary to mark the knot a foot or two less than the true length.

The mode of heaving the log to measure a ship's rate is as follows:—The log-reel, upon which the line is wound, being held by one of the sailors, the officer places himself on the rail to leeward, and, a third person holding the glass, he proceeds to prepare the quadrangular float, so that the peg of one of the lines holding it in a perpendicular direction will draw out, by the force of the water, when the reel is stopped, and allow it to haul in easily. Then, having gathered a sufficient quantity of line into his hand, he throws it far to leeward, that it may not be affected by the eddies which follow in the wake. The stray-line, which allows the ship to get astern, now runs off, and the instant that the white rag, which marks its termination, passes through the hand of the officer, he cries, "Turn!" and continues to veer out line until the glass runs out, and the person holding it cries, "Stop!" Then the line is grasped, and the number of knots that have passed off mark the speed of the ship. When this exceeds five miles, it is customary to use a glass of fifteen instead of thirty seconds, counting the knots double. The rate of sailing per hour, multiplied by the number of hours, thus gives the measure of his run.

In addition to these essential instruments for directing the course and ascertaining the distance, the navigator must be provided with octants of double reflection, to measure the altitude of the

heavenly bodies; and a circle, or sextant, more delicately graduated, to measure distances between the moon and stars. He should also have with him a book containing the logarithms of numbers, sines, tangents, and secants, to facilitate trigonometrical calculation; tables for correcting altitudes for dip, parallax, and refraction; also lists of latitudes and longitudes for every part of the world; and of time of high-water at every port, at the period of full and change of the moon, from which at all times to be able to find the tide; and a variety of tables, to facilitate the various problems of navigation. He should also have with him an astronomical almanac, containing the places and declinations of the fixed stars and planets, and especially the distances of the moon from the sun and other stars, and all that relates to that body, with a view to calculate the longitude by observation. Finally, he must be provided with the general and local charts applicable to his contemplated voyage. Thus furnished, the mariner may set sail with confidence; many do so with no other aids than their compass, log, quadrant, a single chart, and a book of navigation, and arrive in safety: but it is less our business to show with how little care a ship may be navigated than to show how she may be carried from port to port with the greatest possible certainty.

Having taken leave of the port, and when the last land is about to disappear from view, in consequence either of the growing distance or the intervention of night, the mariner selects some conspicuous headland, of which the latitude and longitude are noted in his tables, and placing a compass in some elevated position, remote from any iron object to disturb its polarity, proceeds to determine its bearing, and estimate his distance from it, either by the progress made from it or by the ready estimate of a practised eye. Or, taking the simultaneous bearings of two distinct points of coast, he has still surer data for deducing his position. This is called *taking the departure*, and is carefully noted on the logslate, with the time of making the observation. Thenceforth the log is thrown every hour, and the course and distance are entered upon the slate, to be copied into the log-book at the end of the day.

The first thing which the navigator attends to, after making the offing which prudence dictates to clear the dangers of the land, is to shape his course for the port of his destination. And first he searches in the chart whether there be any point of land, island, or rock, intervening in his way. If there be, the course is primarily shaped with reference to the danger; if not, the differences of latitude and longitude between the two places being taken, the course and distance are obtained by the aid of trigonometry. The shortest distance between any two places on the surface of our sphere is the arc of a great circle passing through those two places. Thus, between Cape Henry, in latitude 37°, and the island of St. Mary, in the same latitude but 50° long. further east, the distance is thirty miles less in sailing on a great circle than in sailing due east on a parallel of latitude, and consequently on a lesser circle of the sphere. In a higher latitude, the difference between sailing on a great or small circle becomes more considerable, as the small circles grow smaller; thus, in the latitude of 60°, a distance equal to that between Cape Henry and St. Mary would offer a disparity of nearly 200 miles. But, as it is only in sailing on the equator, or on a meridian, that the compass points uniformly along a great circle of the sphere, in most cases it would be necessary to change the course at short intervals, in order to attain even an approximation towards this desideratum. For instance, in sailing from Cape Henry to St. Mary, on a great circle, it would first be necessary to sail more than a point northward of east, gradually approaching the direction towards the middle of the distance, when the course should be due east; thence declining southward, until the land would be made upon a course as much south of east as, on starting, it was north of it.

In high latitudes, when the reduction of distance would offer a sufficient inducement, it may be advantageous to attempt following a great circle; but, in the seas ordinarily traversed by mariners, the trifling increase of distance which results from following a uniform course, as obtained by Mercator's sailing, is far more than compensated by its convenience and freedom from all perplexity. For the rest, the wind not unfrequently deprives the fastidious navigator of all choice between a great circle and a loxodromic. At the first noon succeeding the time of taking his departure, the mariner works up his reckoning. This is an epoch fixed by nature, being determined by the passage of the sun over the meridian, and is therefore well chosen as the beginning of the day. The log-slate being marked, he copies the courses and distances, if from head winds or other cause they have been various; the departure from the land is also converted into a course; as is the current, if there be any known one. He next proceeds to find the difference of latitude and departure from the meridian corresponding to each course, either by geometrical calculation, or, more expeditiously, by reference to tables; then he adds the several differences of latitude and departure, and if they be of different names, as some north and some south, some east and others west, deducts the less from the greater. With the remaining difference of latitude and departure, he not only finds the course and distance made good, but also his present situation. The difference of latitude being applied to the latitude left, by adding or subtracting in sailing from or towards the equator, at once gives the latitude of the ship. But, before the departure can be thus applied to find the longitude, it is necessary to reduce it for the converging of the meridian toward the poles; for, though all degrees of longitude are divided, like those of latitude, into sixty minutes or miles, yet they decrease in length, from being equal to a degree of latitude at the equator until they become nothing at the poles. There are many ways, more or less accurate, of deducing the difference of longitude from the departure, the latitude being known; they are founded upon this principle: the circumference of the earth at the equator is to its circumference at any given parallel of latitude as the departure is to the difference of longitude.

The most easy and correct way of obtaining the difference of longitude, on an oblique course, is by the aid of a table of meridional parts; for, having taken out the meridional difference of latitude, the mariner has this simple proportion: the proper difference of latitude is to the meridional difference of latitude as the departure is to the difference of longitude. The difference of longitude, thus obtained, is applied to the longitude left, adding or subtracting,

in sailing to or from the first meridian, and the result will be the ship's longitude, which, with the latitude previously ascertained, determines her position on the chart. The method of navigating thus described is called *dead reckoning*. It is far from infallible, and leaves much to desire. It will, indeed, do pretty well in short runs; but as errors daily creep in from many causes escaping calculation, such as bad steerage, leeway, heave of the sea, unknown currents, and as these accumulate and become considerable at the end of a long voyage, it becomes necessary for the mariner, removed from all reference to terrestrial objects, to resort to the immovable guides in the heavens, whose motions the God that placed them there has given him capacity to comprehend.

Let us now see how the ship's position on the ocean, represented by latitude and longitude, may at any time, without reference to course sailed, or distance, to capricious winds or stealthy currents, be ascertained with ease and accuracy. And, in the first place, to find the latitude, we have abundant data. All the heavenly bodies are, by the revolution of the earth, daily brought to the meridian, at which time, if their altitude be measured, their declination or distance from the equinox being known, the latitude is readily deduced; it may also be deduced from single or double altitudes of bodies not in the meridian, the times being accurately known. But the meridian altitude of the sun is what furnishes at once the easiest and most correct method of finding the latitude.

The meridian altitudes of the stars, and frequently of the moon, must be taken at night, when the horizon is vaguely marked; moreover, their minuteness and want of brilliancy make observation troublesome and uncertain; but, when the sun comes to the meridian, the observer brings a brilliant and palpable object down to a well-defined horizon; then, too, he has the advantage of observing, at a self-fixed epoch, the beginning of a new day. So great, indeed, are the advantages offered by the meridian altitude of the sun, that no other means of finding the latitude are used, except when these have failed from a clouded atmosphere, or when the momentary expectation of making the land quickens the mariner's anxiety. We shall, therefore, now explain the method of deducing the latitude from the sun's meridian altitude. Furnished with a sextant, circle, or octant of reflection, the observer goes upon deck, and, having examined the adjustment of his instrument, proceeds to bring down the image of the sun reflected by its mirror, until the lower limb just sweeps the horizon. He continues to follow and measure its ascent, until it ceases to rise; the moment that it begins to fall, and the lower limb dips in the horizon, the sun has passed the meridian.

The altitude marked by the index being read off, it is next corrected. And, first, the observer adds the semi-diameter, in order to make the altitude apply to the centre of the object; next, he subtracts the dip, to meet the error caused by the extension of the horizon, in consequence of the rotundity of the earth and the elevation of his eye above its surface; also the refraction of the atmosphere, by which the object, when not vertical, is made to appear higher than its true place; lastly, he adds the parallax (a small correction, inconsiderable from the sun's distance), in order to reduce the calculation for the centre of the earth, for which point all calculations are made, and which is ever supposed to be the station of an observer. Having made all these corrections, which many mariners despatch summarily, by an addition of twelve minutes, he has the true meridian altitude of the sun. Taking this from a quadrant, or ninety degrees, gives its zenith distance, or distance from that point in the heavens which is immediately over the observer, and would be met by a straight line passing from the centre of the earth through his position. Now, if the sun were for ever on the equinoctial, the zenith distance would always be the latitude; for, whilst the zenith is the observer's position, referred to the heavens, the equator is there in like manner represented by the equinoctial; and we have already seen that latitude is the distance from the equator. But, as the sun is only twice a year upon the equinoctial, and as his distance from it at times increases to more than twenty degrees, it becomes necessary to take this distance (called his *declination*) into the estimate. The sun's declination is given, in the almanac, for the noon of each day; by correcting it for the time anticipated or elapsed, according as the sun comes first to him or to the first meridian, by his position east or west of it, the observer obtains the declination for noon at his own position. This declination applied to the zenith distance, by adding when the sun is on the same side of the equator, by subtracting when on the opposite side, gives the true latitude.

A daily and accurate knowledge of his latitude is, then, to the mariner of our day, a desideratum of easy attainment. By its aid, nothing is easier than to sail clear of any rock or shoal that crosses his track, either by a watchful look-out at the moment of passing its latitude, or else by avoiding its parallel entirely, until it be surely passed. Moreover, this is his best and surest guide in aiming at his destined port; for he has but to attain the exact latitude it lies in, and then sail directly upon it, east or west, to be sure of success. And here nature is again his friend: by a singular coincidence, discoverable in glancing at the map of the world, most coasts and continents lie in a northern and southern direction. Hence the value attached, by seamen, to an accurate knowledge of the latitude; and hence the nautical phrase of "Latitude, lead, and look-out." But, if it be possible to obtain the longitude with any thing like an equal ease and certainty, no one will dispute its advantage.

Various ways have been devised to find the longitude, in all of which the great element is time. Inasmuch as the earth performs her diurnal revolution in twenty-four hours from the time any given meridian is brought under the sun until it reaches it again, it follows that twenty-four hours and 360 degrees are both equal to a circle, and that the equator and other circles of longitude may be indifferently estimated by either of these divisions. Hence the difference of time between two places is no other than the difference between the sun's coming to their respective meridians, or, in a word, their difference of longitude; and hence it follows that if we, by any means, simultaneously ascertain the time at the first meridian and the time on board ship, we shall have ascertained the longitude. The easiest method of solving this problem is by means of the chronometer. This is a watch so nicely constructed as to go with perfect uniformity, either having no error whatever, or else losing or gaining a known quantity every day. This

watch is set to the time of the first meridian, and its rate is carefully ascertained, before leaving the land. To find the longitude by means of it, the mariner has merely to take an observation of the sun or other star, when rising or falling rapidly, and deduce the time of ship; this, compared with the time at the first meridian, simultaneously given by the chronometer, determines the longitude. Several chronometers concurring with each other may make the mariner sure of his position; but a single one, unchecked by other data, and liable, from its nicety of construction, to easy derangement, is a dangerous guide. The most expeditious and certain way of observing the longitude is by the eclipses of Jupiter's satellites. Their times of immersion and emersion at the first meridian are noted in the almanac, and these, compared with the times at which the telescope shows the observer the occurrence of the same phenomena, determine the longitude. But the unsteadiness of a ship at sea deprives the mariner of this expeditious method. Fortunately, there yet remains open to him one of sufficient accuracy: this is by observing the distance of the moon from the sun and other fixed stars, and comparing the time of observation with that time at which the almanac shows a similar distance for the first meridian. The only difficulty attending this beautiful method, which the rapid movement of the moon in her orbit, and her consequent change of distance from the stars, renders proportionably correct, consists in the first place in nicely observing the distance, and then in correcting it trigonometrically for the errors occasioned by parallax and refraction.

A single lunar observation, like a single chronometer, has been confided in to the loss of many a gallant ship; but a series of them, taken from day to day, with stars on different sides of the moon, and concurring to show the same longitude, are worthy of all confidence. Thus, aided by these heavenly guides, is the mariner at all times able to determine his position. He should not, however, be inattentive to any means of information; he should, by observing the difference between the magnetic bearing of some heavenly body, and what calculation shows to be its true bearing, daily inform himself of that wonderful phenomenon,—the magnetic variation; he should, in calm weather, ascertain the direction and force of the current, by lowering a boat and anchoring it to an iron vessel let down below the superficial strata of the ocean; in approaching the land, he should be attentive to the changing colour and temperature of the sea, which last is, especially on our coast, an admirable monitor; also to the floating of weeds, and the flight of birds, such as do not stray far from it. All these little cares, the watching of the barometer, and profiting by its friendly predictions, and the frequent inspection of the chart, whilst they take from the dangers of navigation, amuse the mariner, and beguile the tedium of the sea. Thus, then, is a ship conducted from port to port; thus are dangers avoided and difficulties overcome. Though they who traverse the vast ocean leave neither track nor waymark for the guidance of those who follow, it is thus converted into a plain and convenient highway, extending to the extremities of the earth. (See the article SHIP.)

NEAPED; the situation of a ship which is left aground on the height of a spring tide, so that she cannot be floated off till the return of the next spring.

NEAP TIDES are those which happen when the moon is nearly at the second and fourth quarters. The *neap* tides are low tides, in respect to their opposites, the *spring* tides.

NEBULA. The name of *nebulæ* is given to certain little spots, resembling white clouds, which are seen in the starry heavens, and which, as observed through the telescope, present three kinds of appearances. These appearances are either that of single stars enveloped in a nebulous veil, or of groups of little stars, or only of a glittering cloud. The last are the proper nebulæ, which astronomers consider as systems of fixed stars, of which there may be innumerable multitudes in infinite space. Herschel, who spent much time in observing them, and has described them in his *Catalogue of One Thousand new Nebulæ* (London, 1786, 4to.), does not consider them all as groups of stars. At present as many as 2000 are known.

NECK; that portion of the human frame which unites the head and the body. Several of the vertebræ of the spine belong to the neck; the first of them has the name of *atlas*, from its immediately supporting the head. Its upper side has two cavities, into which the apophyses of the os occipitis are received; but these two cavities together, unlike all other joints, are laterally portions of concentric circles, by which means they are but as one joint, and so suffer the head to move easily side-ways, which otherwise it could no more do than the knee, which also has two heads and two cavities. The under side of this bone has a very flat articulation with the next; by which means it is fitted for a rotary motion. The superior vertebræ of the neck being fixed behind the head's centre of gravity, the neck is so far bent forward as that the last of these vertebræ, which has a firm bearing upon those of the thorax, falls exactly under the centre of gravity.

NECROMANCY; the divination of the future by questioning the dead. This, like many superstitious rites, originated in the east, or the extreme north, and is of the highest antiquity. Some have, indeed, maintained that it was not brought from Egypt or Persia to Greece, but originated in the last-named country; but it is difficult to prove this. We find mention made of necromancy in the Old Testament; for instance, in the first book of Samuel (i. 18), and in Deuteronomy (xviii. 11), where it is forbidden. In the eleventh book of the Odyssey, Homer has made Ulysses raise the shade of Tiresias from the infernal regions. The rite as there described contains nothing magical, and consists merely in the performance of a sacrifice with peculiar solemnities. This description of Homer proves that necromancy was common in Greece before his time. In many parts of Greece there were oracles of the dead, the origin of which is lost in the obscurity of history. The fable of the descent of Orpheus to Hades is by some considered to refer to this species of necromancy. Indeed, it is very doubtful whether the expression used of many of the Greek heroes, that they descended to the infernal regions, means any thing more than that they consulted an oracle of the dead. While in the rest of Greece necromancy was practised in the temples by priests or other religious persons, individuals called ψυχαγωγοι (evokers of spirits) practised it in Thessaly, the native country of magic, and made use of magical practices. In later times, these practices became horrible; for magicians ascribing a

superior power to human blood, and every thing which came from the gibbet or the grave, were led to the most revolting and disgusting acts. They tore men, half burnt, from their funeral piles, buried others living, ripped out unborn babes from the wombs of their mothers, and committed other similar enormities. They frequently butchered men, in order to consult their spirits before they had time to hasten down to the regions of the dead. After the total downfall of paganism, men were satisfied with a kind of necromancy by which they merely caused the voices of the dead to be heard from their graves.

NECROSIS. This word, the strict meaning of which is simply mortification, is by the general consent of surgeons confined to the mortification of the bones. It was first used in this particular sense by the celebrated M. Louis, who restricted its application, however, to cases in which the whole thickness of the bone was destroyed. By the ancients, the death of parts of bones was not distinguished from caries. However, necrosis and caries are essentially different; for, in the former, the affected part of the bone is deprived of the vital principle; but this is not the case when it is simply carious. Caries is very analogous to ulceration, while necrosis closely resembles mortification of the soft parts.

Between caries and necrosis, says Weidmann, there is all that difference which exists between ulcers and gangrene, or sphacelus, of the soft parts. In caries, the nutrition of the bone is only impaired, and an irregular action disunites the elements of the bony structure, which consequently sustains a loss of substance; but every remaining part of it is yet alive. In necrosis, on the contrary, the vitality and nutritive functions cease altogether in a certain portion of the bone, the separation of which then becomes indispensable.

We have already mentioned that M. Louis confined the term necrosis to cases in which the whole thickness of a bone perished; but Weidmann judiciously criticises this limitation of the word, and maintains that the nature of the disorder is the same whether it affects a single scale, the whole, or a mere point, of the bone. He also objects to the definition of necrosis proposed by Chopart, and adopted by David. These two authors have defined necrosis to be a disorder in which a portion of bone perishes, and turns dry, in order to be soon separated from the living parts, and replaced by a new bony substance, which is to perform its functions. But, as Weidmann observes, it may happen that a piece of bone which dies and separates may not be replaced by any new formation of bone, though the disease is of the same character, and merely varies in some modifications. He therefore argues that a true necrosis must always be said to exist whenever a dead portion of bone has either separated or is about to separate.

The tibia, femur, lower jaw, clavicle, humerus, fibula, radius, and ulna, are the bones most frequently affected with necrosis. Excepting the lower jaw and scapula, the process of regeneration has been noticed only in the cylindrical bones. From twelve to eighteen years of age is the time of life most subject to necrosis. In some persons, two bones are affected at once, owing to constitutional causes.

In the treatment of necrosis, the first grand object of the surgeon should be to aid nature in her endeavours to effect a cure, and not to disturb her operations by any superfluous or unseasonable interference. The second should be to assist her, sometimes by the boldest proceedings, when she loses her way, and cannot by herself accomplish the end. But, in order not to attempt any thing wrong, the surgeon must understand correctly what nature does in this disease, what it is in her power to perform, what she either cannot accomplish at all or not with any degree of certainty, and lastly the circumstances in which she may err, and endanger the patient's life.

When a portion of bone dies, nature uses all her endeavours to bring about its separation from the part of the bone which still remains alive. Surgeons have denominated this process *exfoliation*, which resembles the separation that occurs between parts affected with gangrene and sphacelus, and the living flesh. An exfoliation of bone, however, happens much more slowly than the separation of a slough of the soft parts. Neither are all exfoliations completed at a regular period; for they proceed most quickly during youth, when the constitution is more full of energy, and the bones more vascular and less replete with solid inorganic earthy matter. On the other hand, the process is slower in old or debilitated subjects, whose vitality is less active.

When the disease presents itself with violent symptoms, the inflammation and fever being intense, the severity of the case is to be assuaged by low diet, antiphlogistic remedies, emollient applications, and venesection in moderation, the disease being one which is of long duration and apt to wear out the patient's strength. Here, perhaps, topical bleeding ought always to be preferred to venesection. When the necrosis has arisen from syphilis, scrofula, or scurvy, &c., the medicines calculated for the cure of these affections must be exhibited, ere any favourable changes can be expected in the state of the diseased bone.

Lastly, it is the duty of the practitioner to extract the fragments of dead bone, in order that the deficiencies produced by them may be filled up, and the ulcers of the soft parts healed. Nature, who succeeds by herself in detaching the dead pieces of bone, can do very little in promoting their passage outward. Frequently, indeed, she has no power at all in this process, and it is only from surgery that assistance can be derived. When a dead piece of bone is still adherent at some points, its extraction should be postponed until it has become completely loose. If it were forcibly pulled away, there would be danger of leaving a part of it behind, which must have time to separate ere the cure can be accomplished. But, when a fragment is entirely detached, and the orifices of the sores are sufficiently large, it is to be taken hold of with a pair of forceps, and extracted. When the ulcer has only a very narrow opening, suitable incisions must be made in order to facilitate the removal of the loose dead bone.

NEGATIVE SIGN. This sign implies that the real value of the quantity represented by the letter to which it is prefixed is to be subtracted; and it serves with the positive sign to keep in view what elements or parts enter into the composition of quantities. It serves to express a quantity of an opposite quality to the positive (as a line in a contrary position, a motion with an opposite direction, or a centrifugal force in opposition to gravity), and thus often saves the trouble of distinguishing and demonstrating separately the various cases of proportions, and preserves their analogy in view. But as the proportions

of lines depend on their magnitude only without regard to their position, and motions and forces are said to be equal or unequal in any given ratio without regard to their directions, and in general the proportion of quantity relates to their magnitude only, without determining whether they are to be considered as increments or decrements, so there is no ground to imagine any other proportion of $-b$ and $+a$ (or of -1 and $+1$) than of the real magnitudes of the quantities represented by b and a, whether these quantities are in any particular case to be added or subtracted. It is the same thing to subtract a decrement as to add an equal increment, or to subtract $-b$ from $a-b$, as to add $+b$ to it; and, because multiplying a quantity by a negative number implies only a repeated subtraction of it, the multiplying $-b$ by $-n$ is subtracting $-b$ as often as there are units in n, and is therefore equivalent to adding $+b$ so many times, or the same as adding $+nb$. But if we infer from this that 1 is to $-n$ as $-b$ to nb, according to the rule that unit is to one of the factors as the other factor is to the product, there is no ground to imagine that there is any mystery in this, or any other meaning than that the real magnitudes represented by 1, n, b, and nb are proportional; for that rule relates only to the magnitude of the factors and product, without determining whether any factor or the product is to be added or subtracted. But this likewise must be determined in algebraic computations: and this is the proper use of the rules concerning the signs, without which the operation could not proceed. As a quantity to be subtracted is never produced in composition by any repeated addition of a positive, or repeated subtraction of a negative, a negative square number is never produced by composition from the root. Hence $\sqrt{-1}$, or the square root of a negative, implies an imaginary quantity; and, in resolution, is a mark or character of the impossible cases of a problem, unless it is compensated by another imaginary symbol or supposition, when the whole expression may have a real signification. Thus $1+\sqrt{-1}$, and $1-\sqrt{-1}$ taken separately are imaginary, but their sum is 2; as the conditions that separately would render the solution of a problem impossible in some cases destroy each other's effect when conjoined. In the pursuit of general conclusions, and of simple forms representing them, expressions of this kind must sometimes arise where the imaginary symbol is compensated in a manner that is not always so obvious.

Nephriticum Lignum. This wood is brought from America in large compact pieces of a whitish or pale yellow colour without, and of a dark brownish or reddish colour within. If bruised and macerated in water, it imparts a deep tincture, appearing, when placed betwixt the eye and the light, of a golden colour, but in other situations of a fine blue, a property by which it differs from all other known woods. Other woods are often mixed with it, which only give a yellow tincture. With rectified spirit of wine the same blue tincture is procured, becoming yellow by adding an acid, but again blue by an alkali.

To the taste it is slightly bitter, and the raspings have a faint aromatic smell. A strong infusion in water is gently astringent, and is recommended in nephritic complaints and all disorders of the kidneys and urinary passages. It does not, like the warmer diuretics, increase inflammation.

Nerves. The nerves of the animal frame are composed of bundles of white parallel medullary threads. Every bundle is surrounded with a soft sheath full of blood-vessels, and whose finest branches terminate in the substance of the nerves. These nerves are spread through the whole animal frame, and variously connected with each other. Only the epidermis, the hair, and nails, are destitute of them. They are of various size, according as they are composed of more or fewer bundles of medullary threads. In the course of the nerves there are a number of knots; these are called *ganglions;* they are commonly of an oblong shape, and of a grayish colour, somewhat inclining to red, which is perhaps owing to their being extremely vascular. In particular parts of the body the nerves come in contact with each other, and the bundles composing them are mutually interwoven to such a degree that they cannot be disjoined without violence. These communications are called *plexuses*, and are found particularly in the abdomen, behind the stomach, and in the region of the pit of the stomach, near the liver, mesentery, heart, &c.

The final terminations of the nerves are various, particularly those which run to the organs of sense. In the auricular organ, for instance, the nerves terminate in a soft mass like pap, surrounded with moisture; the optic nerve terminates in a medullary skin; the nerves of taste terminate in little *papillæ;* those of feeling in the points of the fingers and the surface of the skin in general; those belonging to the muscles are lost in the texture of the same, so that their terminations cannot be accurately ascertained.

All the nerves are embraced under the general head of the *nervous system.* This is most intimately connected with the brain and the spinal marrow, which may be regarded as a prolongation of it. The brain is the centre, from which or to which proceed all impressions communicated to the nerves. The substance of the nerves is the same medullary matter which constitutes the brain, resembling the white of an egg, and appearing to the unassisted eye as if composed of little balls. The central termination of all the nerves is in the brain and spinal marrow, where they branch out into the skin or the interior of the organs. The various isolated, and in part heterogeneous, structures of which the body consists, which are mechanically joined by the cellular tissue, the membranes, and the ligaments, are united into one harmonious whole by means of the nerves. The vascular system connects them only so far as it furnishes the supply of blood required for their support and their operations; but it is properly the nervous system which imparts to all their life, governs their operations, and establishes their sympathy and mutual action. This is effected by means of that portion of the nervous system which is diffused through the abdomen, forming many nets and plexuses, and constituting what is called the *vegetative*, or *reproductive*, or *organic nervous system*, because the growth and support of the body are effected by it.

Another part of the nervous system affords the means of consciousness and voluntary action. This is the *brain* or *cerebral system*, which excites the nerves that put in action the muscles of voluntary motion, and those which supply sensibility to the organs of sense, and convey to the brain the impressions thence received. The nerves which communicate with the organs of sense run in pairs—the

first pair (olfactory nerve) to the nose, where it is spread over the surface of the nostrils, and forms the power of smell; the second (optic nerve) to the eyes; this is round, thick, and penetrates from behind the ball or globe of the eye (through a round plate of the firm coat of the ball, containing many little apertures), and is spread out on the inner and concave surface of the globe into a thin coat called the *retina*, on which the images of external objects are formed; the eighth pair (auditory nerves) are spread over the interior of the ear, and are sensible to the vibrations of the air.

From the numerous ramifications of the ninth pair come the nerves of the tongue, which give rise to the sense of taste. The general sense of feeling is situated particularly in the skin, and peculiarly in the points of the fingers. This sense is produced by a variety of nerves diffused over the skin, and those parts which are most sensitive are supplied with the greatest quantity of nerves, which form entire series of contiguous nervous *papillæ;* for instance, at the lips, the points of the fingers, &c. Thus the action of the nerves is reciprocal from without inwards, and from within outwards—the first, because the impressions on the organs of sense are communicated by the nerves to the brain, and there form perceptions and feelings; the second, because the voluntary motions are produced by communications from the brain to the nerves, while the reproductive part of the nervous system quietly supports the whole machine, and, in a sound state of the body, is recognized only by the operation of the appetites, and by a general feeling of ease throughout the system, but, in a diseased state, gives rise to general uneasiness and pain.

The power of the nervous system has no fixed point, but is variable, even in the same subject. In sleep, the activity of the cerebral system is impaired, that of the reproductive system heightened; therefore, in quiet sleep, the operations of the senses and the voluntary motions cease, while the activity of the organs of respiration and circulation, of digestion, secretion, and nourishment continues. From what has been said, it must be obvious that the whole action of the body depends upon the nervous system. (See PHYSIOLOGY and PHRENOLOGY.)

NERVOUS DISEASES (*neuroses*) are such as consist in disturbed affections of sense and motion, unattended by any chronic or acute inflammation, or hemorrhage, or by any disturbance of the circulation. Nervous pains are called *neuralgiæ; spasms* are involuntary contractions in organs which have muscular fibres, or which are merely susceptible of contraction; *convulsions* are involuntary and irregular contractions, alternating with relaxations, in one, or several, or all of the muscles, simultaneously or successively; *tetanus* is a permanent contraction of a certain class of muscles, ordinarily followed by death; *contraction* is a retraction of the flexor muscles of one member or of two parallel members; *paralysis* is the diminution or loss of the sensibility of an organ of sense, or the contractility of an organ of motion. The pains, spasms, paralysis, take different names, according to the parts affected. The most remarkable of all the *neuroses* is *apoplexy,* which is characterized by the suspension or successive loss of sense and understanding, as well as of motion. The affections of the mind, known under the names of *mental alienation, insanity, idiocy,* &c., are also *neuroses;* that is, disturbances in the action of the nervous system. It has been asserted that nervous diseases are rendered more common by the progress of civilization; and, in fact, the nerves become more irritable, and therefore more liable to be diseased, with the progress of intelligence. But the refinements of the moderns in their food and drinks, the use of fermented liquors, wine, coffee, and tea, are the most frequent causes of nervous maladies. The early and excessive use of these liquids provokes the nerves, diseases the stomach, and gives rise to cerebral fevers in children, to the vapours or hysterics in women, and to hypochondria, apoplexy, and paralysis in men. It is not always easy to distinguish the symptoms of *neurosis* from those of inflammation; but, as the treatment in the two cases must be entirely different, it is of the greatest importance to use every caution in this respect. Particular medicines, which were considered as specific remedies in nervous diseases, were formerly in use; but experience has proved that warm bathing, soothing drinks, vegetable diet, exercise, recreation, sometimes bleeding, at others rubefacients, opium in a few cases, when the pain is great, and Peruvian bark, are the best antagonists of *neurosis.* The treatment of nervous diseases, however, has not a little embarrassed the scientific practitioner, as they often resist the most skilful and sagacious applications.

NET, in *commerce;* that which remains of a weight, quantity, &c., after making certain deductions. Thus, in mercantile language, the *net weight* is the weight of any article after deducting tare and tret; *net profit, income,* &c., is the absolute profit or income after deducting expenses, interest, &c. It is opposed to *gross.*

NETHERLAND SCHOOL OF PAINTING includes all the painters in the Netherlands who, since the fourteenth and fifteenth centuries, have pursued their art in a style peculiar to that country. It is divided into the *Dutch* and the *Flemish* schools. The Flemish school was founded by John van Eyk, and is distinguished by a brilliant colouring; magical effect of the *chiaro-scuro;* carefully laboured, though often tasteless drawing; a strong, yet natural expression, and boldness in composition. To this school belong Francis Floris (born 1520, died 1570), called the *Flemish Raphael;* John Stradanus (de Straet), of Bruges (born 1536), who painted historical pieces and hunting scenes; Mart. de Vos (born 1520); Spranger (born 1546); Peter and Francis Porbus, father and son; Dionysius Calvart; the brothers Paul and Matthew Brill; Van Ort (born 1557); Peter Breughel and his son John; Roland Savery, of Courtray (born in 1576). After these came Peter Paul Rubens, the boldest painter of modern times; a man of inexhaustible industry, of gigantic imagination, and power of representation, to whom about 4000 paintings are ascribed. With him the Flemish school reached its acme. Several distinguished painters follow: Francis Snyders (born 1579), whose hunting pieces excel all others in boldness and truth; Jodocus Momper (born 1580), a landscape painter, esteemed for his valleys and the distant views which they present; Peter Neefs, the famous church painter; David Teniers, father and son, who, in representing companies of peasants, guard-rooms, tap-houses, and all kinds of low life, have hardly their equal; Gaspar de Crayer (born 1582), who approaches, in the expression and colouring of his historical paintings, to Rubens; Gerard Segers, distinguished as a historical painter; his brother Daniel, famous for flower and

insect pieces. James Jordaens (born 1594), however, excelled all those who made Rubens their model. Abraham Janssen, and his pupil Theodore Rombouts (greater than his teacher), equal Rubens in colouring, but not in conception. The industrious Luke van Uden executed the landscapes for Ruben's paintings; and his views of the sky at dawn are worthy the study of every artist.

Anthony van Dyk (born 1599) obtained the name of the *king of portrait painters*. He excelled Rubens in correctness and beauty of forms. Cornelius Schüt, for whom John Wildens often painted the landscapes, distinguished himself as a historical painter; Adrian Brouwer acquired fame by his excellent representations of scenes from common life; John van der Meer by his pastoral pieces; Anthony Francis van der Meulen by his battle pieces; Francis and John Milet, father and son, by their landscapes. Besides these, we might mention the names of John Bol, Wenceslaus Koeberger, Henry Goltzius, Henry van Balen, Francis Hals, William Nieuwland, James Fouquieres, Philip de Champagne, Erasmus Quellin, Abraham Diepenbeck, Theod. van Thulden, John Goeimar, James of Artois, Bonewent Peters, David Kickaert, Gonzalez Coques, Peter Boel, Samuel van Hoogstraaten, John Bapt. Monoyer, Abraham Genoels, Gerard Lairesse, Arnold von Vuez, John Francis van Bloemann, John van Cleef, Pet. Eykens, Richard van Orley, Louis Deyster, Nicholas Largillière, Verendael, Robert van Oudenaerde, John Anthony van der Leepe, Caspar Verbrügen, John van Breda.

The Dutch school is distinguished for a faithful copying of nature, great finish, good *chiaro-scuro* and skilful disposition of colours, and delicate pencilling; but it is reproached with choosing ignoble subjects, and with incorrectness of drawing. Its founder is Luke of Leyden (born 1494). Its most prominent artists are Octavius van Veen, of Leyden (born 1586, died 1634), who deserves mention also as the teacher of Rubens. Abraham Bloemart, of Gorcum (died 1647), painted historical subjects, landscapes, and animals, in good taste. Cornelius Poelenburg, of Utrecht (born 1586, died 1663), was peculiarly happy in painting small landscapes with figures.

John Weynants, of Haarlem (born 1600), is distinguished as a landscape painter; and John Daniel de Heem, of Utrecht (born 1604, died 1674), for his faithful imitation of flowers, fruits, carpets, vases, &c. The highest place belongs to Rembrandt, whose masterly colouring atones for all his defects, and Hermann Sachtleben, who painted fine landscapes. In the delineation of common life, the following are distinguished:—Gerard Terburg, of Zwoll (born 1608, died 1681); in landscapes, John Both, of Utrecht (born 1610, died 1650); Hermann Swaneveld, of Woerden (born 1620, died 1690). Asselyn (born 1610, died 1680) painted battles, landscapes, and pastoral pieces, with a brilliant colouring and a delicate pencil. But it will be difficult to find any painter who draws more correctly, colours more beautifully, and distributes light more truly, than Gerhard Dow, or Douw (born 1613, died 1680).

Peter van Laar was the inventor of the *Bambocciate;* John Fyt (born at Antwerp, 1625) was a good painter of beasts, birds, and fruits; Gabriel Metzu, who worked in the style of Terburg, excelled him in softness of pencilling. The landscapes of Benenberg of Utrecht are full of life and freshness. Phillip Wouvermann (born 1620, died 1668), the most famous painter of horses, produced battle and hunting pieces, horse-markets, travellers, and robbers; and his paintings, of all kinds, are highly esteemed. His pupil John Griffer painted the beautiful views on the Rhine. The landscapes of Anthony Waterloo, for which Weenix executed the figures, are sometimes cold, but please on account of the accuracy with which he represents light playing through foliage, and the reflection of objects in water.

Berghen acquired the name of the *Theocritus of painters;* and perhaps Paul Potter is the only one who can dispute the superiority with him. Whilst Ludolf Backhuysen painted storms at sea with an effect as true as it is terrible, Francis Mieris distinguished himself by fine and accurate representations of many domestic subjects, and John Peter Slingeland was hardly more accurate. Godfrey Schalken, of Dort, has not yet been excelled in the illumination of night scenes. Excellent market scenes, animals, and landscapes were painted by Charles du Jardin. Adrian van de Velde painted landscapes and animals with almost unequalled perfection. For the representation of the beautiful solitudes of nature, James Ruisdael is celebrated; and for quiet, lovely, moonlight scenes, Van der Neer: the former is one of the most successful painters that ever attempted to portray nature. No painter has painted more delicately, and with more finish, even in insignificant trifles, than Adrian van der Werf. The flower painter Peter van Hulst, of Dort, is not equal to James van Huysum, who is almost unrivalled in this department.

Among the modern painters, we should mention Van Os, Van Spaendonk, Scheffer, Pienemann, Hoges, Kuipers, Ommegang, Van Bree, Wonder, Schotels. Pienemann's picture, the Battle of Waterloo (eighteen feet wide, and twenty-five high), was bought by the king of Holland for 40,000 guilders, for the purpose of being presented to the duke of Wellington.

The reproach of an almost exclusive adherence to common reality has been often applied to the whole school of the Netherlands; but it is confined by some to the Dutch; whilst the Flemish school, they say, in its more elevated productions, has striven to represent a nobler nature. The chief question in painting, however, is not what the artist attempts, but what he accomplishes; and, if George Foster is right in saying that in the works of the Flemish painters we generally miss the spirit of the poet in the beauty of the manual execution, then the Dutch school would deserve the preference, because, though it takes most of its subjects from common reality, it often represents them with a poetic conception of their character. It would be better, however, to describe them both as deficient in ideal beauty, but as distinguished, in the highest degree, for faithful imitation of nature. There would still remain sufficient distinction between the two schools. That they both have great merit in respect to the technical part of the art has never been doubted; and that they have greater merits, to a much higher degree than is generally allowed them, will be evident from a careful study.

Neutralization, in *chemistry*, may be thus explained:—If we take a given quantity of sulphuric acid diluted with water, and add it slowly to the solution of soda by little at a time, and examine the mixture after every addition, we shall find that for a considerable time it will exhibit the properties of an acid,

reddening vegetable blues, and having a taste perceptibly sour; but these acid properties gradually diminish after every addition of the alkaline solution, and at last disappear altogether. If we still continue to add the soda, the mixture gradually acquires alkaline properties, converting vegetable blues to green, and manifesting a urinous taste. These properties become stronger and stronger the greater the quantity of the soda is which is added. Thus it appears that when sulphuric acid and soda are mixed together the properties either of the one or the other preponderate, according to the proportions of each; but there are certain proportions according to which, when they are combined, they mutually destroy or disguise the properties of each other, so that neither predominates, or rather so that both disappear. When substances thus mutually disguise each other's properties, they are said to *neutralize* one another. This property is common to a great number of bodies; but it manifests itself most strongly, and was first observed, in the acids, alkalies, and earths. Hence the salts which are combinations of these different bodies received long ago the name of *neutral salts*.

NEWTONIAN PHILOSOPHY. As the doctrines of our great English philosopher have long since acquired the stamp and impress of truth, it may be proper to furnish our readers with a condensed view of what has in this country been styled the *Doctrine of the Universe*.

The term *Newtonian philosophy* is applied very differently by different authors. Some view it as the corpuscular philosophy, corrected and reformed by the discoveries and improvements made by Sir Isaac Newton. In this sense it is that Gravesande calls his elements of physics *Introductio ad Philosophiam Newtonianam*. And in this sense the Newtonian is the same with the new philosophy, and stands contradistinguished from the Cartesian, the Peripatetic, and the ancient Corpuscular. Others, by Newtonian philosophy, mean the method or order which its great founder observed in philosophising; viz. the reasoning and drawing of conclusions directly from phenomena, exclusive of all previous hypotheses; the beginning from simple principles; deducing the first powers and laws of nature from a few select phenomena, and then applying those laws, &c., to account for other things. And in this sense the Newtonian philosophy is the same with the experimental philosophy, and stands opposed to the Corpuscular. Others, again, by Newtonian philosophy mean that in which physical bodies are considered mathematically, and where geometry and mechanics are applied to the solution of the appearances of nature, in which sense the Newtonian is the same with the mechanical and mathematical philosophy.

The whole of the *Newtonian philosophy*, as delivered by the author, is contained in his *Principia*, or *Mathematical Principles of Natural philosophy*. He founds his system on the following definitions:—1. The quantity of *matter* is the measure of the same arising from its density and bulk conjointly. Thus air of a double density, in a double space, is quadruple in quantity; in a triple space, sextuple in quantity, &c. 2. The quantity of *motion* is the measure of the same, arising from the velocity and quantity of matter conjointly. This is evident, because the motion of the whole is the motion of all its parts; and therefore in a body double in quantity, with equal velocity, the motion is double, &c. 3. The innate force of matter is a power of resistance, by which every body, as much as in it lies, endeavours to persevere in its present state, whether it be of rest or moving uniformly forward in a right line. 4. An *impressed force* is an action exerted upon a body, in order to change its state, either of rest or of moving uniformly forward in a right line. This force consists in the action only, and remains no longer in the body when the action is over; for a body maintains every new state it acquires by its *vis inertiæ* only. 5. A *centripetal* force is that by which bodies are drawn, impelled, or any way tend towards a point, or to a centre. The quantity of any centripetal force may be considered as of three kinds, absolute, accelerative, and motive. 6. The *absolute* quantity of a centrifugal force is a measure of the same proportional to the efficacy of the cause that propagates it from the centre through the spaces round about. 7. The accelerative quantity of a centripetal force is a measure of the same proportional to the velocity which it generates in a given time. 8. The motive quantity of a centripetal force is a measure of the same proportional to the motion which it generates in a given time. This is always known by the quantity of a force equal and contrary to it, that is, just sufficient to hinder the descent of the body.

SCHOLIUM I. Absolute, true, and mathematical *time*, of itself, and from its own nature, flows equably, without regard to any thing external, and, by another name, is called *duration*. Relative, apparent, and common time, is some sensible and external measure of duration, whether accurate or not, which is commonly used instead of true time; such as an hour, a day, a month, a year, &c.

II. Absolute *space*, in its own nature, without regard to any thing external, remains always similar and immovable. Relative space is some movable dimension or measure of the absolute spaces, and which is vulgarly taken for immovable space. Such is the dimension of a subterraneous, an aërial, or celestial space, determined by its position to bodies, and which is vulgarly taken for immovable space; as the distance of a subterraneous, an aërial, or celestial space, determined by its position in respect of the earth. Absolute and relative space are the same in figure and magnitude; but they do not remain always numerically the same. For if the earth, for instance, moves, a space of our air which, relatively and in respect of the earth, remains always the same, will at one time be one part of the absolute space into which the earth passes, at another time it will be another part of the same; and so, absolutely understood, it will be perpetually mutable.

III. A *place* is a part of space which a body takes up; and is, according to the space, either absolute or relative. Our author says it is *part* of space; not the situation nor the external surface of the body. For the places of equal solids are always equal; but their superficies, by reason of their dissimilar figures, are often unequal. Positions properly have no quantity, nor are they so much the places themselves as the properties of places. The motion of the whole is the same thing with the sum of the motions of the parts; that is, the translation of the whole out of its place is the same thing with the sum of the translations of the parts out of their places: and therefore the place of the whole is the same thing with the sum of the places of the parts;

and for that reason it is internal, and in the whole body.

IV. Absolute *motion* is the translation of a body from one absolute place into another; and relative motion the translation from one relative place into another. Thus, in a ship under sail, the relative place of a body is that part of a ship which the body possesses, or that part of its cavity which the body fills, and which therefore moves together with the ship; and relative rest is the continuance of the body in the same part of the ship, or of its cavity. But real absolute rest is the continuance of the body in the same part of that immovable space in which the ship itself, its cavity, and all that it contains, is moved. Wherefore, if the earth be really at rest, the body which relatively rests in the ship will really and absolutely move with the same velocity which the ship has on the earth. But, if the earth also move, the true and absolute motion of the body will arise partly from the true motion of the earth in immovable space, partly from the relative motion of the ship on the earth: and, if the body move also relatively in the ship, its true motion will arise partly from the true motion of the earth in immovable space, and partly from the relative motions as well of the ship on the earth as of the body in the ship; and from these relative motions will arise the relative motion of the body on the earth.

Absolute *time*, in astronomy, is distinguished from relative, by the equation or correction of the vulgar time. For the natural days are truly unequal, though they are commonly considered as equal, and used for a measure of time: astronomers correct this inequality for their more accurate deducing of the celestial motions. It may be that there is no such thing as an equable motion whereby time may be accurately measured. All motions may be accelerated or retarded; but the true or equable progress of absolute time is liable to no change.

As the order of the parts of time is immutable, so also is the order of the parts of space. Suppose those parts to be moved out of their places, and they will be moved (if we may be allowed the expression) out of themselves. For times and spaces are, as it were, the places of themselves as of all other things. All things are placed in time as to order of succession, and in space as to order of situation. It is from their essence or nature that they are places; and that the primary places of things should be movable is absurd. These are therefore the absolute places; and translations out of those places are the only absolute motions.

But, because the parts of space cannot be seen or distinguished from one another by the senses, therefore in their stead we use sensible measures of them. For, from the positions and distances of things from any body, considered as immovable, we define all places; and then, with respect to such places, we estimate all motions, considering bodies as transferred from some of those places into others. And so, instead of absolute places and motions, we use relative ones, and that without any inconvenience in common affairs: but in philosophical disquisitions we ought to abstract from our senses, and consider things themselves distinct from what are only sensible measures of them. For it may be that there is no body really at rest, to which the places and motions of others may be referred.

But we may distinguish rest and motion, absolute and relative, one from the other, by their properties, causes, and effects. It is a property of rest that bodies really at rest do rest in respect of each other. And therefore, as it is possible that in the remote regions of the fixed stars, or perhaps far beyond them, there may be some body absolutely at rest, though it be impossible to know from the position of bodies to one another in our regions whether any of these do keep the same position to that remote body, it follows that absolute rest cannot be determined from the position of bodies in our regions.

It is a property of motion that the parts which retain given positions to their wholes do partake of the motion of their wholes. For all parts of revolving bodies endeavour to recede from the axis of motion; and the impetus of bodies moving forwards arises from the joint impetus of all the parts. Therefore, if surrounding bodies be moved, those that are relatively at rest within them will partake of their motion, upon which account the true and absolute motion of a body cannot be determined by the translation of it from those only which seem to rest; for the external bodies ought not only to appear at rest, but to be really at rest, otherwise all included bodies, beside their translation from near the surrounding ones, partake likewise of their true motions; and, though that translation was not made, they would not really be at rest, but only seem to be so. For the surrounding bodies stand in the like relation to the surrounded as the exterior part of a whole does to the interior, or as the shell does to the kernel; but, if the shell move, the kernel will also move, as being part of the whole, without any removal from near the shell.

A property near akin to the preceding is that if a place is moved, whatever is placed therein moves along with it; and therefore a body which is moved from a place in motion partakes also of the motion of its place, upon which account all motions from places in motion are no other than parts of entire and absolute motions; and every entire motion is composed of the motion of the body out of its first place and the motion of this place out of its place; and so on, until we come to some immovable place, as in the previous example of the ship. Wherefore entire and absolute motions can be no otherwise determined than by immovable places. Now, no other places are immovable but those that from infinity to infinity do all retain the same given positions one to another, and upon this account must ever remain unmoved, and do thereby constitute what we call *immovable space*.

The causes by which true and relative motions are distinguished one from the other are the forces impressed upon bodies to generate motion. True motion is neither generated nor altered but by some force impressed upon the body moved: but relative motion may be generated or altered without any force impressed upon the body; for it is sufficient only to impress some force on other bodies with which the former is compared, that, by their giving way, that relation may be changed in which the relative rest or motion of the other body did consist. Again, true motion suffers always some change from any force impressed upon the moving body; but relative motion does not necessarily undergo any change by such force. For if the same forces are likewise impressed on those other bodies with which the comparison is made, that the relative position may be

preserved, then that condition will be preserved in which the relative motion consists. And therefore any relative motion may be changed when the true motion remains unaltered, and the relative may be preserved when the true motion suffers some change, upon which account true motion does by no means consist of such relations.

The powers which distinguish absolute from relative motion may be exemplified by the action of the centrifugal force. For there are no such forces in a circular motion purely relative: but, in a true and absolute circular motion, they are greater or less according to the quantity of the motion. If a vessel, hung by a long cord, be so often turned about that the cord is strongly twisted, then filled with water, and let go, it will be whirled about the contrary way; and, while the cord is untwisting itself, the surface of the water will at first be plain, as before the vessel began to move; but the vessel, by gradually communicating its motion to the water, will make it begin sensibly to revolve, and recede by little and little from the middle, and ascend to the sides of the vessel, forming itself into a concave figure; and the swifter the motion becomes the higher will the water rise, till at last, performing its revolution in the same times with the vessel, it becomes relatively at rest in it. This ascent of the water shows its endeavour to recede from the axis of its motion; and the true and absolute circular motion of the water, which is here directly contrary to the relative, discovers itself, and may be measured by this endeavour. At first, when the relative motion of the water was greatest, it produced no endeavour to recede from the axis; the water showed no tendency to the circumference, nor any ascent towards the sides of the vessel, but remained with a plain surface; and therefore its true circular motion had not yet begun. But afterwards, when the relative motion of the water had decreased, the ascent thereof towards the sides of the vessel proved its endeavour to recede from the axis; and this endeavour showed the real circular motion of the water perpetually increasing, till it had acquired its greatest amount, when the water rested relatively in the vessel. And therefore this endeavour does not depend upon any translation of the water in respect of the ambient bodies; nor can true circular motion be defined by such translations. (See Whirling Table.) There is only one real circular motion of any one revolving body, corresponding to only one power of endeavouring to recede from its axis of motion, as its proper and adequate effect; but relative motions in one and the same body are innumerable, according to the various relations it bears to external bodies; and, like other relations, are altogether destitute of any real effect, otherwise than they may perhaps participate of that only true motion. And therefore, in the system which supposes that our heavens, revolving below the sphere of the fixed stars, carry the planets along with them, the several parts of those heavens and the planets, which are indeed relatively at rest in their heavens, do yet really move, for they change their position one to another, which never happens to bodies truly at rest; and being carried together with the heavens participate of their motions, and, as parts of revolving wholes, endeavour to recede from the axis of their motion.

Wherefore relative quantities are not the quantities themselves whose names they bear, but those sensible measures of them, either accurate or inaccurate, which are commonly used instead of the measured quantities themselves. And then, if the meaning of words is to be determined by their use, by the names *time*, *space*, *place*, and *motion*, their measures are properly to be understood; and the expression will be purely mathematical if the measured quantities themselves be meant.

It is indeed a matter of great difficulty to discover, and effectually to distinguish, the true motions of particular bodies from those that are only apparent, because the parts of that immovable space in which those motions are performed do by no means come under the observation of our senses. Yet we have some things to direct us in this intricate affair, and these arise partly from the apparent motions which are the difference of the true motions, partly from the forces which are the causes and effects of the true motions. For instance, if two globes, kept at a given distance one from the other by means of a cord that connects them, were revolved about their common centre of gravity, we might, from the tension of the cord, discover the endeavour of the globes to recede from the axis of motion, and from thence we might compute the quantity of their circular motions. And then, if any equal forces should be impressed at once on the alternate faces of the globes to augment or diminish their circular motions, from the increase or decrease of the tension of the cord we might infer the increment or decrement of their motions; and thence would be found on what faces those forces ought to be impressed, that the motions of the globes might be most augmented; that is, we might discover their hindermost faces, or those which follow in the circular motion. But the faces which follow being known, and consequently the opposite ones that precede, we should likewise know the determination of their motions. And thus we might find both the quantity and determination of this circular motion, even in an immense vacuum where there was nothing external or sensible with which the globes might be compared. But now, if in that space some remote bodies were placed that kept always a given position one to another, as the fixed stars do in our regions, we could not indeed determine from the relative translation of the globes among those bodies whether the motion did belong to the globes or to the bodies. But if we observed the cord, and found that its tension was that very tension which the motion of the globes required, we might conclude the motion to be in the globes and the bodies to be at rest; and then, lastly, from the translation of the globes among the bodies we should find the determination of their motions.

Having thus explained himself, Sir Isaac proposes to show how we are to collect the true motions from their causes, effects, and apparent differences; and, *vice versâ*, how from the motions, either true or apparent, we may come to the knowledge of their causes and effects. In order to this, he lays down the following axioms or laws of motion :—

1. *Every body perseveres in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed upon it.*—Sir Isaac's proof of this axiom is as follows: "Projectiles persevere in their motions so far as they are not retarded by the resistance of the air, or impelled downwards by the force of gravity. A top, whose parts, by their cohesion, are perpetually drawn aside from a rectilinear motion, does not cease its rotation other-

wise than as it is retarded by the air. The greater bodies of the planets and comets, meeting with less resistance in free space, preserve their motions, both progressive and circular, for a much longer time."

2. *The alteration of motion is ever proportional to the motive force impressed, and is made in the direction of the right line in which that force is impressed.*—Thus, if any force generates a certain quantity of motion, a double force will generate a double quantity, whether that force be impressed all at once or in successive moments. To this law no objection of consequence has ever been made. It is founded on this self-evident truth, that every effect must be proportional to its cause.

3. *To every action there always is opposed an equal re-action, or the mutual action of two bodies upon each other are always equal and directed to contrary parts.*—This axiom has been disputed by many. "When an action generates no motion," Mr. Young says, "it is certain that its effects have been destroyed by a contrary and equal action. When an action generates two contrary and equal motions it is also evident that mutual actions were exerted equal and contrary to each other. All cases where one of these conditions is not found are exceptions to the truth of the law. If a finger presses against a stone, the stone, if it does not yield to the pressure, presses as much upon the finger: but if the stone yields it re-acts less than the finger acts; and if it should yield with all the momentum that the force of the pressure ought to generate, which it would do if it were not impeded by friction or a medium, it would not re-act at all. So if the stone drawn by a horse follows after the horse, it does not re-act so much as the horse acts, but only so much as the velocity of the stone is diminished by friction, and it is the re-action of friction only, not of the stone. The stone does not re-act, because it does not act: it resists, but resistance is not action.

"In the loss of motion from a striking body, equal to the gain in the body struck, there is a plain solution without requiring any re-action. The motion *lost* is identically that which is *found* in the other body; this supposition accounts for the whole phenomenon in the most simple manner. If it be not admitted, but the solution by re-action is insisted upon, it will be incumbent on the party to account for the whole effect of communication of motion, otherwise he will lie under the imputation of rejecting a solution which is simple, obvious, and perfect, for one complex, unnatural, and incomplete. However this may be determined, it will be allowed that the circumstances mentioned afford no ground for the inference that action and re-action are equal, since appearances may be explained in another way."

Others grant that Sir Isaac's axiom is very true in respect to terrestrial substances, but they affirm that in these both action and re-action are the effects of gravity. Substances void of gravity would have no momentum, and without this they could not act; they would be moved by the least force, and therefore could not resist or re-act. "If therefore there is any fluid which is the cause of gravity, though such fluid could act upon terrestrial substances, yet these could not re-act upon it, because they have no force of their own, but depend entirely upon it for their momentum. In this manner, say they, we may conceive that the planets circulate, and all the operations of nature are carried on by means of a subtile fluid, which being perfectly active, and the rest of matter altogether passive, there is neither resistance nor loss of motion."

From the preceding axiom Sir Isaac draws the following corollaries:—

1. A body by two forces conjoined will describe the diagonal of a parallelogram in the same time that it would describe the sides by those forces apart.

2. Hence we may explain the composition of any one direct force out of any two oblique ones, viz. by making the two oblique forces the sides of a parallelogram, and the direct one the diagonal.

3. The quantity of motion which is collected by taking the sum of the motions directed towards the same parts, and the difference of those that are directed to contrary parts, suffers no change from the action of bodies among themselves, because the motion which one body loses is communicated to another; and, if we suppose friction and the resistance of the air to be absent, the motion of a number of bodies which mutually impelled one another would be perpetual and its quantity always equal.

4. The common centre of gravity of two or more bodies does not alter its state of motion or rest by the actions of the bodies among themselves, and therefore the common centre of gravity of all bodies acting upon each other (excluding outward actions and impediments) is either at rest or moves uniformly in a right line.

The motions of bodies included in a given space are the same among themselves, whether that space is at rest or moves uniformly forward in a right line without any circular motion. The truth of this is evidently shown by the experiment of a ship, where all motions happen after the same manner, whether the ship is at rest or proceeds uniformly forward in a straight line.

6. If bodies, any how moved among themselves, are urged in the direction of parallel lines by equal accelerative forces, they will all continue to move among themselves after the same manner as if they had been urged by no such forces.

The mathematical part of the Newtonian philosophy may be said to depend on the following lemmas, of which the first is the principal:—

LEM. I. Quantities and the ratios of quantities, which in any finite time converge continually to equality, and before that time approach nearer the one to the other than by any given difference become ultimately equal.

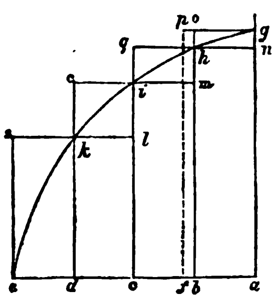
"These lemmas," observes Sir Issac Newton, "are premised, to avoid the tediousness of deducing perplexed demonstrations *ad absurdum*, according to the method of ancient geometers. For demonstrations are more contracted by the method of indivisibles: but because the hypothesis of indivisibles seems somewhat harsh, and therefore that method is reckoned less geometrical, I chose rather to reduce the demonstrations of the following propositions to the first and last sums and ratios of nascent and evanescent quantities, that is, to the limits of those sums and ratios; and so to premise, as short as I could, the demonstration of those limits. For thereby the same thing is performed as by the method of indivisibles; and now, those principles being demonstrated, we may use them with more safety. Therefore, if hereafter I should happen to consider quantities as made up of particles, or should use little curve lines for right ones, I would not be understood to mean indivisibles, but evanescent divisible quantities; not

the sums and ratios of determined parts, but always the limits of sums and ratios; and that the force of such demonstrations always depends on the method laid down in the foregoing lemmas.

"Perhaps it may be objected that there is no ultimate proportion of evanescent quantities, because the proportion, before the quantities have vanished, is not the ultimate, and, when they have vanished, is none. But by the same argument it may be alleged that a body arriving at a certain place, and there stopping, has no ultimate velocity; because the velocity before the body comes to the place is not its ultimate velocity; when it is arrived, it has none. But the answer is easy: for by the ultimate velocity is meant that with which the body is moved neither before it arrives at its place and the motion ceases, nor after, but at the very instant it arrives; that is, that velocity with which the body arrives at its last place, and with which the motion ceases. And in like manner, by the ultimate ratio of evanescent quantities is to be understood the ratio of the quantities, not before they vanish, nor afterwards, but with which they vanish. In like manner, the first ratio of nascent quantities is that with which they begin to be. And the first or last sum is that with which they begin and cease to be (or to be augmented and diminished). There is a limit which the velocity at the end of the motion may attain, but not exceed; and this is the ultimate velocity: and there is the like limit in all quantities and proportions that begin and cease to be. And, since such limits are certain and definite, to determine the same is a problem strictly geometrical. But whatever is geometrical we may be allowed to make use of in determining and demonstrating any other thing that is likewise geometrical.

"It may be also objected that, if the ultimate ratios of evanescent quantities be given, their ultimate magnitudes will be also given; and so all quantities will consist of indivisibles, which is contrary to what Euclid has demonstrated concerning incommensurables, in the tenth Book of his Elements. But this objection is founded on a false supposition; for those ultimate ratios with which quantities vanish are not truly the ratios of ultimate quantities, but limits towards which the ratios of quantities decreasing continually approach."

LEM. II. If in the figure *a g i e*, terminated by the right lines *a g*, *a e*, and the curve *g i e*, there be inscribed any number of parallelograms, *a h*, *b i*, *c k*, &c., comprehended under equal bases, *a b*, *b c*, *c d*, &c., and the sides *b h*, *c i*, *d k*, &c., parallel to one side, *a g*, of the figure; and the parallelograms *g n h o*, *h m i q*, *i l k c*, &c., are completed; then if the breadth of these parallelograms be supposed to be diminished, and their number augmented *in infinitum*, the ultimate ratios which the inscribed figure *a n h m i l k d*, the circumscribed figure *a g o b q i c k s e*, and curvilinear figure *a g h i k e*, will have to one another, are ratios of equality. For the difference

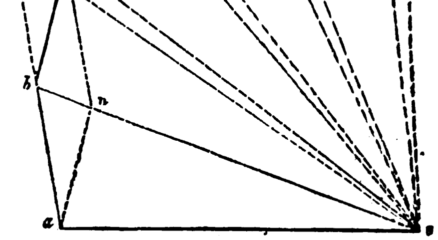


of the inscribed and circumscribed figures is the sum of the parallelograms *n o*, *m q*, *l c*, *d s*; that is (from the equality of all their bases), the rectangle under one of their bases *n h*, and the sum of their altitudes *a g*, that is, the rectangle *a b g o*. But the breadth of the rectangle in the direction *a b* is supposed to be diminished *ad infinitum*, so that, by lem. I., the figures inscribed and circumscribed become ultimately equal the one to the other; and much more will the intermediate curvilinear figure be ultimately equal to either.

LEM. III. The same ultimate ratios are also ratios of equality, when the breadths *a b*, *b c*, *c d*, &c, of the paralellograms are unequal, and are all diminished *ad infinitum*. The demonstration of this differs but little from that of the former.

In his succeeding lemmas, Sir Isaac goes on to prove, in a manner similar to the above, that the ultimate ratios of the sine, chord, and tangent of arcs infinitely diminished, are ratios of equality, and therefore that in all our reasonings about these we may safely use the one for the other: that the ultimate form of evanescent triangles made by the arc, chord, and tangent, is that of similitude, and their ultimate ratio is that of equality; and hence, in reasoning about ultimate ratios, we may safely use these triangles for each other, whether made with the sine, the arc, or the tangent. He then shows some properties of the ordinates of curvilinear figures; and proves that the spaces which a body describes by any finite force urging it, whether that force is determined and immutable, or is continually augmented or continually diminished, are, in the very beginning of the motion, one to the other in the duplicate ratio of the powers. And, lastly, having added some demonstrations concerning the evanescence of angles of contact, he proceeds to lay down the mathematical part of his system, and which depends on the following theorems:—

THEOR. I. The areas which revolving bodies describe by radii drawn to an immovable centre of force lie in the same immovable planes, and are proportioned to the times in which they are described.



For, suppose the time to be divided into equal parts, and in the first part of that time let the body by its innate force describe the right line *a b*; in the se-

cond part of that time the same would, by law 1, if not hindered, proceed directly to *g*, along the line *b c a b*; so that by the radii *a s b*, *s g s*, drawn to the centre, the equal areas *a s b*, *b s g*, would be described. But, when the body is arrived at *b*, suppose the centripetal force acts at once with a great impulse, and, turning aside the body from the right line *b g*, compels it afterwards to continue its motion along the right line *b c*. Draw *g c* parallel to *b s*, meeting *b c* in *c*; and at the end of the second part of the time the body, by cor. 1 of the laws, will be found in *c*, in the same plane with the triangle *a s b*. Join *s c*; and, because *s b* and *c i* are parallel, the triangle *s b c* will be equal to the triangle *s c d*, and therefore also to the triangle *s a b*. By the like argument, if the centripetal force act successively in *c d i*, &c., and make the body in each single particle of time to describe the right lines *c d*, *d e*, *e f*, &c., they will lie in the same plane, and the triangle *s c d* will be equal to the triangle *s b c*, and *s d e* to *s c d*, and *s e f* to *s d e*. And therefore, in equal times, equal areas are described in one immovable plane; and, by composition, any sums, *s a d*, *s a f*, of those areas are, one to the other, as the times in which they are described. Now let the numbers of those triangles be augmented, and their size diminished *in infinitum*; and then, by the preceding lemmas, their ultimate perimeter *a d f* will be a curve line; and therefore the centripetal force by which the body is perpetually drawn back from the tangent of this curve will act continually; and any described areas *s a d*, *s a f*, which are always proportional to the times of description, will, in this case also, be proportional to those times.

Cor. 1. The velocity of a body attracted towards an immovable centre, in spaces void of resistance, is reciprocally as the perpendicular let fall from that centre on the right line which touches the orbit. For the velocities in these places *a*, *b*, *c*, *d*, *e*, are the bases *a b*, *b c*, *d e*, *e f* of equal triangles; and these bases are reciprocally as the perpendiculars let fall upon them.

Cor. 2. If the chords *a b*, *b c*, of two arcs successively described in equal times by the same body, in spaces void of resistance, are completed into a parallelogram, *a b c n*, and the diagonal *b n* of this parallelogram, in the position which it ultimately acquires when those arcs are diminished *in infinitum*, is produced both ways, it will pass through the centre of force.

Cor. 3. If the chords *a b*, *b c*, and *d e*, *e f*, of arcs described in equal times, in spaces void of resistance, are completed into the parallelograms *a b c n*, *d e f m*, the forces in *b* and *e* are one to the other in the ultimate ratio of the diagonals *b n*, *e m*, when those arcs are diminished *in infinitum*. For the motions *b c* and *e f* of the body (by cor. 1 of the laws) are compounded of the motions *b c*, *b n*, and *e l*, *e m*; but *b n* and *e m*, which are equal to *c g* and *f l* in the demonstration of this proposition, were generated by the impulses of the centripetal force in *b* and *e*, and are therefore proportional to those impulses.

Cor. 4. The forces by which bodies, in spaces void of resistance, are drawn back from rectilinear motions, and turned into curvilinear orbits, are one to another as the versed sines of arcs described in equal times, which versed sines tend to the centre of force, and bisect the chords when these arcs are diminished to infinity. For such versed sines are the halfs of the diagonals mentioned in cor. 3.

Cor. 5. And therefore those forces are to the force of gravity as the said versed sines to the versed sines perpendicular to the horizon of those parabolic arcs which projectiles describe in the same time.

Cor. 6. And the same things do all hold good (by cor. 5 of the laws) when the planes in which the bodies are moved, together with the centres of force, which are placed in those planes, are not at rest, but move uniformly forward in right lines.

Theor. II. Every body that moves in any curve line described in a plane, and which, by a radius drawn to a point either immovable or moving forward with a uniform rectilinear motion, describes about that point areas proportional to the times, is urged by a centripetal force directed to that point.

Case I. For every body that moves in a curve line is (by law 1) turned aside from its rectilinear course by the action of some force that impels it; and that force by which the body is turned off from its rectilinear course, and made to describe in equal times the least equal triangles *s a b*, *s b c*, *s c d*, &c., about the immovable point *s* (by prop. 40, E. 1, and law 2), acts in the place *b* according to the direction of a line parallel to *c* (that is, in the direction of the line *b s*), and in the place *c* according to the direction of a line parallel to *h d* (that is, in the direction of the line *c s*), &c., and therefore acts always in the direction of lines tending to the immovable point *s*.

Case II. And (by cor. 5 of the laws) it is indifferent whether the superficies in which a body describes a curvilinear figure be quiescent or moves together with the body, the figure described, and its point *s*, uniformly forward in right lines.

Cor. 1. In nonresisting spaces or mediums, if the areas are not proportional to the times, the forces are not directed to the point in which the radii meet; but deviate therefrom *in consequentia*, or towards the parts to which the motion is directed, if the description of the areas is accelerated; but *in antecedentia* if retarded.

Cor. 2. And even in resisting mediums, if the description of the areas is accelerated, the direction of the forces deviates from the point in which the radii meet towards the parts to which the motion tends.

Scholium. A body may be urged by a centripetal force compounded of several forces; in which case the meaning of the proposition is that the force which results out of all tends to the point *s*. But, if any force act perpetually in the direction of lines perpendicular to the described surface, this force will make the body to deviate from the plane of its motion, but will neither augment nor diminish the quantity of the described surface, and is therefore not to be neglected in the composition of forces.

Theor. III. Every body that, by a radius drawn to the centre of another body, however moved, describes areas about that centre proportional to the times, is urged by a force compounded of the centripetal forces tending to that other body, and of all the accelerative force by which that other body is impelled. The demonstration of this is a natural consequence of the theorem immediately preceding.

Hence, if a body L, by a radius drawn to another body T, describes areas proportional to the times, and if from the whole force by which the first body L is urged (whether that force is simple, or, according to cor. 2 of the laws, compounded of several forces) we subduct that whole accelerative

force by which the other body is urged, the whole remaining force by which the first body is urged will tend to the other body T as its centre. And, *vice versâ*, if the remaining force tend nearly to the other body T, those areas will be nearly proportional to the times.

If the body L, by a radius drawn to the other body T, describe areas which, compared with the times, are very unequal, and that other body T is either at rest or moves uniformly forward in a right line, the action of the centripetal force tending to that other body T is either none at all or it is mixed and combined with very powerful actions of other forces, and the whole force compounded of them all, if they are many, is directed to another (immovable or movable) centre. The same thing obtains when the other body is actuated by any other motion whatever, provided that centripetal force is taken which remains after subducting that whole force acting upon that other body T.

Scholium. Because the equable description of areas indicates that a centre is respected by that force with which the body is most affected, and by which it is drawn back from its rectilinear motion and retained in its orbit, we may always be allowed to use the equable description of areas as an indication of a centre about which all circular motion is performed in free spaces.

Theor. IV. The centripetal forces of bodies which by equable motions describe different circles tend to the centres of the same circles, and are one to the other as the squares of the arcs described in equal times applied to the radii of circles.—For these forces tend to the centres of the circles (by theor. 2 and cor. 2 theor. 1), and are to one another as the versed sines of the least arcs described in equal times (by cor. 4 theor. 1), that is, as the squares of the same arcs applied to the diameters of the circles, by one of the lemmas; and therefore, since those arcs are as arcs described in any equal times, and the diameters are as the radii, the forces will be as the squares of any arcs described in the same time applied to the radii of the circles.

Cor. 1. Therefore, since those arcs are as the velocities of the bodies, the centripetal forces are in a ratio compounded of the duplicate ratio of the velocities directly, and of the simple ratio of the radii inversely.

Cor. 2. And, since the periodic times are in a ratio compounded of the ratio of the radii directly and the ratio of the velocities inversely, the centripetal forces are in a ratio compounded of the ratio of the radii directly and the duplicate ratio of the periodic times inversely.

Cor. 3. Whence, if the periodic times are equal, and the velocities therefore as the radii, the centripetal forces will be also as the radii; and the contrary.

Cor. 4. If the periodic times and the velocities are both in the subduplicate ratio of the radii, the centripetal forces will be equal among themselves; and the contrary.

Cor. 5. If the periodic times are as the radii, and therefore the velocities equal, the centripetal forces will be reciprocally as the radii; and the contrary.

Cor. 6. If the periodic times are in the sesquiplicate ratio of the radii, and therefore the velocities reciprocally in the subduplicate ratio of the radii, the centripetal forces will be in the duplicate ratio of the radii inversely; and the contrary.

Cor. 7. And universally, if the periodic time is as any power R^n of the radius R, and therefore the velocity reciprocally as the power R^{n-1} of the radius, the centripetal force will be reciprocally as the power R^{2n-1} of the radius; and the contrary.

Cor. 8. The same things all hold concerning the times, the velocities, and forces, by which bodies describe the similar parts of any similar figures, that have their centres in a similar position within those figures, as appears by applying the demonstrations of the preceding cases to those. And the application is easy, by only substituting the equable description of areas in the place of equable motion, and using the distances of the bodies from the centres instead of the radii.

Cor. 9. From the same demonstration it likewise follows that the arc which a body uniformly revolving in a circle by means of a given centripetal force describes in any time is a mean proportional between the diameter of the circle and the space which the same body, falling by the same given force, would descend through in the same given time.

By means of the preceding proposition, and its corollaries (says Sir Isaac), we may discover the proportion of a centripetal force to any other known force, such as that of gravity. For, if a body by means of its gravity revolves in a circle concentric to the earth, this gravity is the centripetal force of that body. But from the descent of heavy bodies the time of one entire revolution, as well as the arc described in any given time, is given (by cor. 9 of this theorem). And by such proposition Mr. Huygens, in his excellent book *De Horologio Oscillatorio*, has compared the force of gravity with the centrifugal forces of revolving bodies.

The preceding proposition may also be demonstrated in the following manner:—In any circle suppose a polygon to be inscribed of any number of sides. And if a body, moved with a given velocity along the sides of the polygon, is reflected from the circle at the several angular points, the force with which at every reflection it strikes the circle will be as its velocity; and therefore the sum of the forces, in a given time, will be as that velocity and the number of reflections conjointly; that is (if the species of the polygon be given), as the length described in that given time, and increased or diminished in the ratio of the same length to the radius of the circle (that is, as the square of that length applied to the radius); and therefore, if the polygon, by having its sides diminished *in infinitum*, coincides with the circle, as the square of the arc described in a given time applied to the radius. This is the centrifugal force, with which the body impels the circle, and to which the contrary force, wherewith the circle continually repels the body towards the centre, is equal.

Sir Isaac then shows how to find the centre to which the forces impelling any body are directed, having the velocity of the body given, and finds the centrifugal force to be always as the versed sine of the nascent arc directly, and as the square of the time inversely; or directly as the square of the velocity and inversely as the chord of the nascent arc. From these premises he deduces the method of finding the centripetal force directed to any given point when the body revolves in a circle, and this whether the central point is near or at an immense distance; so that all the lines drawn from it may be taken for parallels.

The same thing he shows with regard to bodies revolving in spirals, ellipses, hyperbolas, or parabolas. Having the figures of the orbits given, he shows also how to find the velocities and moving powers; and, in short, solves all the most difficult problems relating to the celestial bodies with an astonishing degree of mathematical skill. These problems and demonstrations are all contained in the first book of the *Principia:* but to give an account of them here would far exceed our limits; neither would many of them be intelligible, without lengthened mathematical demonstrations.

In the second book Sir Isaac treats of the properties of fluids and their powers of resistance; and here he lays down such principles as entirely overthrow the doctrine of Des Cartes's vortices. In the third book he particularly treats of the phenomena of the heavenly bodies, and applies them to the mathematical principles formerly demonstrated; and, as a necessary preliminary to this part, he lays down the following rules for reasoning in natural philosophy:—

1. We are to admit no more causes of natural things than such as are both true and sufficient to explain their natural appearances.

2. Therefore to the same natural effects we must always assign as far as possible the same causes.

3. The qualities of bodies which admit neither intension nor remission of degrees, and which are found to belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever.

4. In experimental philosophy we are to look upon propositions collected by general induction from phenomena as accurately or very nearly true, notwithstanding any contrary hypotheses that may be imagined, till such time as other phenomena occur by which they may either be made more accurate or liable to exceptions.

The phenomena first considered are, 1. That the satellites of Jupiter, by radii drawn to the centre of their primary, describe equal areas in equal times; and that their periodic times, the fixed stars being at rest, are in the sesquiplicate ratio of their distances from its centre. 2. The same thing is likewise observed of the phenomena of Saturn. 3. The five primary planets, Mercury, Venus, Mars, Jupiter, and Saturn, with their several orbits, encompass the sun. 4. The fixed stars being supposed at rest, the periodic times of the five primary planets, and of the earth about the sun, are in the sesquiplicate proportion of their mean distances from the sun. 5. The primary planets, by radii drawn to the earth, describe areas no ways proportionable to the times; but the areas which they describe by radii drawn to the sun are proportional to the times of description. 6. The moon, by a radius drawn to the centre of the earth, describes an area proportional to the time of description. Sir Isaac Newton then proceeds to the following propositions:—

PROP. I. The forces by which the satellites of Jupiter are continually drawn off from rectilinear motions, and retained in their proper orbits, tend to the centre of that planet, and are reciprocally as the squares of the distances of those satellites from that centre.

PROP. II. The forces by which the primary planets are continually drawn off from rectilinear motions, and retained in their proper orbits, tend to the sun; and are reciprocally as the squares of the distances from the sun's centre. The former part of this proposition is manifest from phenom. 5 and from theor. 2; the latter from phenom. 4 and cor. 6 of theor. 4. But this part of the proposition is with great accuracy deducible from the quiescence of the aphelion points; for a very small aberration from the reciprocal duplicate proportion would produce a motion of the apsides, sensible in every single revolution, and in many of them enormously great.

PROP. III. The force by which the moon is retained in its orbit tends towards the earth, and is reciprocally as the square of the distance of its place from the centre of the earth. The former part of this proposition is evident from phenom. 5 and theor. 2; the latter from phenom. 6 and theor. 2 or 3. It is also evident from the very slow motion of the moon's apogee, which, in every single revolution amounting but to 3° 3′ *in consequentiu,* may be neglected: and this more fully appears from the next proposition.

PROP. IV. The moon gravitates towards the earth, and by the force of gravity is continually drawn off from a rectilinear motion, and retained in its orbit.— The mean distance of the moon from the earth in the syzigies in semi-diameters of the latter is about $60\frac{1}{2}$. Let us assume the mean distance of sixty semi diameters in the syzigies; and suppose one revolution of the moon in respect of the fixed stars to be completed in 27^d 7^h 43′, as astronomers have determined, and the circumference of the earth to amount to 123,249,600 Paris feet. Now, if we imagine the moon, deprived of all motion, to be let go, so as to descend towards the earth with the impulse of all that force by which it is retained in its orbit, it will, in the space of one minute of time, describe in its fall $15\frac{1}{4}$ Paris feet; for the versed sine of that arc which the moon, in the space of one minute of time, describes by its mean motion at the distance of sixty semi-diameters of the earth, is nearly $15\frac{1}{12}$ Paris feet —or, more accurately, 15 feet, 1 inch, 1 line $\frac{4}{9}$. Wherefore since that force, in approaching to the earth, increases in the reciprocal duplicate proportion of the distance, and upon that account at the surface of the earth is 60×60 times greater than at the moon, a body in our regions falling with that force ought, in the space of one minute of time, to describe $60 \times 60 \times 15\frac{1}{12}$ Paris feet; and in the space of one second of time to describe $15\frac{1}{12}$ of those feet— or, more accurately, 15 feet, 1 inch, 1 line $\frac{4}{9}$. And with this very force we actually find that bodies here on earth do really descend; for a pendulum oscillating seconds in the latitude of Paris will be three Paris feet and $8\frac{1}{2}$ lines in length, as Mr. Huygens has observed. And the space which a heavy body describes by falling one second of time is to half the length of the pendulum in the duplicate ratio of the circumference of the circle to its diameter, and is therefore 15 Paris feet, 1 inch, 1 line $\frac{4}{9}$. And therefore the force by which the moon is retained in its orbit becomes, at the very surface of the earth, equal to the force of gravity which we observe in heavy bodies there. And therefore (by rule 1 and 2) the force by which the moon is retained in its orbit is that very same force which we commonly call *gravity*. For, were gravity another force different from that, then bodies descending to the earth with the joint impulse of both forces would fall with a double velocity, and, in the space of one second of time, would describe $30\frac{1}{6}$ Paris feet, which is altogether against experience.

The demonstration of this proposition may be more diffusely explained after the following manner:—Suppose several moons to revolve about the earth, as in the system of Jupiter or Saturn, the periodic times of those moons would (by the argument of induction) observe the same law which Kepler found to obtain among the planets, and therefore their centripetal forces would be reciprocally as the squares of the distances from the centre of the earth by Prop. I. Now, if the lowest of these were very small, and were so near the earth as almost to touch the tops of the highest mountains, the centripetal force thereof, retaining it in its orbit, would be very nearly equal to the weights of any terrestrial bodies that should be found upon the tops of these mountains, as may be known from the foregoing calculation. Therefore, if the same little moon should be deserted by its centrifugal force that carries it through its orbit, it would descend to the earth, and that with the same velocity with which heavy bodies do actually descend upon the tops of those very mountains, because of the equality of forces that oblige them both to descend; and if the force by which that lowest moon would descend were different from that of gravity, and if that moon were to gravitate towards the earth as we find terrestrial bodies do on the tops of mountains, it would then descend with twice the velocity, as being impelled by both these forces conspiring together. Therefore, since both these forces (that is, the gravity of heavy bodies and the centripetal forces of the moons) respect the centre of the earth, and are similar and equal between themselves, they will (by rule 1 and 2) have the same cause; and therefore the force which retains the moon in its orbit is that very force which we commonly call *gravity*, because otherwise this little moon at the top of a mountain must either be without gravity or fall twice as swiftly as heavy bodies use to do.

Having thus demonstrated that the moon is retained in its orbit by its gravitation towards the earth, it is easy to apply the same demonstration to the motions of the other secondary planets, and of the primary planets round the sun, and thus to show that gravitation prevails throughout the whole creation, after which Sir Isaac proceeds to show from the same principles that the heavenly bodies gravitate towards each other, and contain different quantities of matter, or have different densities, in proportion to their bulks.

PROP. V. All bodies gravitate towards every planet; and the weights of bodies towards the same planet, at equal distances from its centre, are proportional to the quantities of matter they may contain.

COR. 1. Hence the weights of bodies do not depend upon their forms and textures. For, if the weights could be altered with the forms, they would be greater or less, according to the variety of forms in equal matter, which is altogether against experience.

COR. 2. Universally, all bodies about the earth gravitate towards the earth; and the weights of all, at equal distances from the earth's centre, are as the quantities of matter which they severally contain. This is the quality of all bodies within the reach of our experiments, and therefore (by rule 3) to be affirmed of all bodies whatsoever. If either, or any other body, were either altogether void of gravity or were to gravitate less in proportion to its quantity of matter, then, because (according to Aristotle, Des Cartes, and others) there is no difference betwixt that and other bodies, but in mere form of matter, by a successive change from form to form, it might be changed at last into a body of the same condition with those which gravitate most in proportion to their quantity of matter; and, on the other hand, the heaviest bodies, acquiring the first form of that body, might by degrees quite lose their gravity. And therefore the weights would depend upon the forms of bodies, and with those forms might be changed, contrary to what was proved in the preceding corollary.

COR. 3. All spaces are not equally full. For, if all spaces were equally full, then the specific gravity of the fluid which fills the region of the air, on account of the extreme density of the matter, would fall nothing short of the specific gravity of quicksilver or gold, or any other the most dense body; and therefore neither gold nor any other body could descend in air: for bodies do not descend in fluids unless they are specifically heavier than the fluids. And if the quantity of matter in a given space can by any rarefaction be diminished, what should hinder a diminution to infinity?

COR. 4. If all the solid particles of all bodies are of the same density, nor can be rarefied without pores, a void space or vacuum must be granted.

PROP. VI. That there is a power of gravity belonging to all bodies, proportional to the several quantities of matter which they contain.

That all the planets mutually gravitate one towards another has been proved before, as well as that the force of gravity towards every one of them, considered apart, is reciprocally as the square of the distance of places from the centre of the planet. And thence it follows that the gravity tending towards all the planets is proportional to the matter which they contain.

Moreover, since all the parts of a planet, *A*, gravitate towards another planet, *B*, and the gravity of every part is to the gravity of the whole as the matter of the part to the matter of the whole, and (by law 3) to every action corresponds an equal reaction, therefore the planet *B* will, on the other hand, gravitate towards all the parts of the planet *A*, and its gravity towards any one part will be to the gravity towards the whole as the matter of the part to the matter of the whole.

COR. 1. Therefore the force of gravity towards any whole planet arises from, and is compounded of, the forces of gravity towards all its parts. This may be easily understood in reference to gravity, if we consider a greater planet as formed of a number of smaller planets meeting together in one globe; for hence it would appear that the force of the whole must arise from the forces of the component parts. If it be objected that according to this law all bodies with us must mutually gravitate one towards another, whereas no such gravitation any where appears, it is answered that, since the gravitation towards these bodies is to the gravitation towards the whole earth as these bodies are to the whole earth, the gravitation towards them must be too small to fall under the observation of our senses.

COR. 2. The force of gravity towards the several equal particles of any body is reciprocally as the square of the distance of places from the particles.

PROP. VII. In two spheres, mutually gravitating each towards the other, if the matter, in places on all sides round about, and equidistant from the centres,

be similar, the weight of either sphere towards the other will be reciprocally as the square of the distance between their centres.

For the demonstration of this, see the *Principia*, book I., prop. 75 and 76.

Cor. 1., Hence we may find and compare together the weights with which bodies are drawn towards different planets. For the weights of bodies revolving in circles about planets are as the diameters of the circles directly and the squares of their periodic times reciprocally, and their weights at the surfaces of the planets, or at any other distances from their centres, are (by this prop.) greater or less in the reciprocal duplicate proportion of the distances. Thus from the periodic times of Venus, revolving about the sun in $224^d\ 16\frac{3}{4}^h$, of the utmost circumjovian satellite revolving about Jupiter in $16^d\ 16\frac{8}{13}^h$, of the Huygenian satellite about Saturn in $15^d\ 22\frac{2}{3}^h$, and of the moon about the earth in $27^d\ 7^h\ 43'$, compared with the mean distance of Venus from the sun and with the greatest heliocentric elongations of the outmost circumjovian satellite from Jupiter's centre (8′ 16″), of the Huygenian satellite from the centre of Saturn (3′ 4″), and of the moon from the earth (10′ 33″), by computation our author found that the weight of equal bodies, at equal distances from the centres of the sun, of Jupiter, of Saturn, and of the earth towards the sun, Jupiter, Saturn, and the earth, were one to another as $\frac{1}{1067}$, $\frac{1}{3021}$, and $\frac{1}{169282}$ respectively. Then, because as the distances are increased or diminished the weights are diminished or increased in a duplicate ratio, the weights of equal bodies towards the sun, Jupiter, Saturn, and the earth, at the distances 10,000, 997, 791, and 109 from their centres (that is, at their very superficies), will be as 10,000, 943, 529, and 435 respectively.

Cor. 2. Hence likewise we discover the quantity of matter in the several planets. For their quantities of matter are as the forces of gravity at equal distances from their centres, that is, in the sun, Jupiter, Saturn, and the earth, as 1, $\frac{1}{1067}$, $\frac{1}{3021}$, and $\frac{1}{169282}$, respectively. If the parallax of the sun be taken greater or less than 10″ 30‴, the quantity of matter in the earth must be augmented or diminished in the triplicate of that proportion.

Cor. 3. Hence also we find the densities of the planets. For (by prop. 72, book 1) the weights of equal and similar bodies towards similar spheres are, at the surfaces of those spheres, as the diameters of the spheres. And therefore the densities of dissimilar spheres are as those weights applied to the diameters of the spheres. But the true diameters of the sun, Jupiter, Saturn, and the earth, were one to another as 10,000, 997, 791, and 109; and the weights towards the same as 10,000, 943, 529, and 435 respectively; and therefore their densities are as 100, 94½, 67, and 400.

It is shown in the scholium of prop. 22 book 2 of the *Principia* that, at the height of 200 miles above the earth, the air is more rare than it is at the superficies of the earth in the ratio of 30 to 0.0000000000003998. And hence the planet Jupiter, revolving in a medium of the same density with that superior air, would not lose by the resistance of the medium the 1,000,000th part of its motion in 1,000,000 years.

In the above view of the Newtonian system of philosophising we have kept as close as possible both to the phraseology and mode of reasoning pursued by the illustrious author, and it forms a curious specimen of the style of argument adopted by the ancient schoolmen.

Nickel a metal whose distinct character was suspected by Cronstedt in 1751, and fully ascertained by Bergman in 1775. The ore in which it was first found, and from which it is principally obtained at present, is the *Kupfer nickel*, or sulphuret of nickel, mixed also with arsenic, iron, and cobalt. The pure metal and its preparations are obtained from this mineral, or from the artificial arseniuret called *speiss*, a metallurgic production derived from the roasted ores of cobalt. The most convenient method for obtaining the metal is that in which the speiss is employed, and was suggested by Dr. Wollaston. Sulphuric acid is added to the pulverized speiss, and nitric acid, also, at intervals, in the proportion of about one fourth part; a green solution is formed, and, after a subsidence of several hours, the green supernatant liquid is decanted and evaporated until crystals of sulphate of nickel are deposited: a further evaporation gives a crust of arseniate and sulphate, which is dissolved in water, and agitated by a current of sulphuretted hydrogen, until precipitation ceases. The fluid is filtered again, and more of the apple-green matter obtained by evaporation, which, when redissolved, becomes opaque, owing to the precipitation of arsenious acid. The fluid is again filtered, evaporated, and suffered to crystallize, when the sulphate of nickel may be relied upon as being entirely pure. This sulphate, being again dissolved, is decomposed by carbonate of soda, and the resulting carbonate made into balls with oil, and surrounded with charcoal in a crucible, and, being heated in a melting furnace for two hours, yields a pure button of nickel. Its colour, in this condition, is between that of silver and tin; and, when polished, its lustre is equal to that of platinum. Nickel is malleable, and can be forged into bars when hot, and hammered into plates when cold; its specific gravity, when cast, is 8.402, and when forged, 8.66. It is capable of being drawn into very fine wire. It is less fusible than iron. In a covered crucible, some of it is volatilized, and appears in drops on the cover of the crucible. It is attractable by the magnet nearly in the same degree as iron, and becomes itself a magnet by touching, hammering, &c. As nickel does not rust, it has a very great superiority over steel in the construction of a compass-needle. There are two oxides of nickle—the dark ash-gray and the black. If potash be added to the solution of the nitrate or sulphate, and the precipitate dried, we obtain the *protoxide*. It may be regarded as a compound of about 100 metal with twenty-eight oxygen.

The *peroxide* was formed by Thénard, by passing chlorine through the protoxide diffused in water: a black insoluble peroxide remains at the bottom. Its colour is a brilliant black. When heated, it loses oxygen, and becomes protoxide. *Sulphuret of nickel*, prepared directly from its elements, is of a yellow colour, like iron pyrites, and brittle. It consists of seventy nickel and thirty sulphur. *Chloride of nickel* is prepared by evaporating the muriate to dryness. It is of a yellow-green colour, and is a protochloride. When calcined in a retort, one portion of an olive-green colour remains in the bottom of the vessel, while another sublimes, and crystallizes in small, light, brilliant plates of a gold-yellow colour; these are the *deutochloride*. An *iodide of nickel* may be obtained by heating iodine and nickel in a tube. It

is a brown substance; fusible; soluble in water, to which it imparts a light-green colour.

The *salts of nickel* possess the following general properties:—They have usually a green colour, and yield a white precipitate with ferroprussiate of potash. Ammonia dissolves the oxide of nickel. Sulphureted hydrogen and infusion of galls occasion no precipitate. The hydrosulphuret of potash throws down a black precipitate. Their composition has been very imperfectly ascertained. The sulphuric and muriatic acids have little action upon nickel. Sulphate of nickel crystallizes very readily. Its primary form is a right-sided square prism. The nitric and nitromuriatic acids are the most appropriate solvents of nickel. The nitric solution is of a pure green colour. Carbonate of potash throws down from it a pale apple-green precipitate, which, when well washed and dried, is very light. When ammonia is added in excess to a nitric solution of nickel, a blue precipitate is formed, which changes to a purple red in a few hours, and is converted to an apple-green by an acid.

The *alloys* of nickel with other metals are unimportant. With gold, in the ratio of twenty grains to an ounce of nickel, a brass-coloured brittle compound is formed. With iron it unites in every proportion. If nickel prevails, the metal is white, and the ductility and magnetism are equal to that of iron. It does not amalgamate with mercury. Pure nickel being dear and rare, it is entirely unknown in common life, and almost so in the arts. It would undoubtedly be applied to useful purposes if it could be found in sufficient quantity. Dobreiner has observed that the metallic alloy, consisting chiefly of arsenic and nickel, which is obtained from the process of fabricating smalt, often crystallizes in four-sided tabular crystals, and is in every respect similar to arsenical nickel.

NICOTINE; a peculiar principle obtained from tobacco. The following process is adopted for obtaining it in a state of purity:—Boil twelve pounds of dry tobacco leaves in water acidulated with sulphuric acid; evaporate and treat the extract with alcohol diluted with a ninth part of water; add a little water to the solution, and distil; add hydrate of lime to the aqueous residuum, and redistil. The product being mixed and agitated with ether, the latter is to be poured off, and a fresh portion added. All the ethereous solutions are to be united, and mixed with muriate of lime, which will take away the water; and the concentrated ethereous solution, being evaporated or distilled, will leave 100 grains of reddish nicotine. It is liquid at 21° Fahrenheit; its odour resembles that of dry tobacco; its taste is very acrid, burning, and durable. It is denser than water, volatilizes in the air, and boils at 417° Fahrenheit. It dissolves in water in all proportions, and the solution has an alkaline reaction. When dissolved in alcohol or ether, and exposed to heat, it does not distil with their vapours. Acids take the nicotine from the ethereous solution, and form salts insoluble in either. It is eminently poisonous.

NICTITATING MEMBRANE, in comparative *anatomy;* a thin membrane, chiefly found in the bird and fish kinds, which covers the eyes of these animals, sheltering them from the dust, or from too much light, yet is so thin and pellucid that they can see pretty well through it.

NIELLO; a species of work used among the Romans and modern Italians, somewhat resembling Damascus work, and performed by enchasing a mixture of silver and lead into cavities and holes cut in all sorts of hard wood and metals. This art was denominated by the ancients *nigellum*, and was used by them to decorate a great variety of things, and more especially *candelabra*. It was practised by the jewellers and goldsmiths, and flourished chiefly in the fifteenth century.

NIGHT. (For the division of the twenty-four hours into day and night, see DAY.) As a telluric phenomenon, night is of the greatest interest, from the sleep which it brings to most organic creatures; the life to which others awake with it; the increase of feverish symptoms on its arrival, and many other phenomena. One of the most interesting of these is the greater clearness with which distant sounds are heard during night. This fact, which had been observed by the ancients, and in large cities, or their vicinity, was commonly ascribed to the repose of animated beings. When Humboldt first heard the noise of the great cataracts of the Orinoco, in the plain which surrounds the Mission of the Apures, his attention was particularly directed to this curious fact, and he was of opinion that the noise was three times louder at night than during the day. As the humming of insects was much greater at night than during the day, and as the breeze which agitated the leaves of the trees never rose till after sunset, this eminent traveller was compelled to seek for another cause of the phenomenon. In a hot day, when warm currents of air ascend from the heated ground, and mix with the cold air above, of a different density, the transparency of the air is so much affected that every object seen through it appears to be in motion, just as when we look at any object over a fire or the flame of a candle. The air is, therefore, during the day, a mixed medium in which the sounds are reflected and scattered in passing through streams of air of different densities, as in the experiment of mixing atmospheric air and hydrogen. At midnight, on the contrary, when the air is transparent, and of uniform density, as may be seen by the brilliancy and number of the stars, the slightest sound reaches the ear without interruption.

M. Chladni has illustrated the effect of a mixed medium by an elegant experiment of easy repetition. If we pour sparkling Champagne into a tall glass till it is half full, the glass cannot be made to ring by a stroke upon its edge, but admits a dull, disagreeable, and puffy sound. This effect continues as long as the effervescence lasts, and while the wine is filled with air-bubbles. But, as the effervescence subsides, the sound becomes clearer and clearer, till at last the glass rings as usual, when the air-bubbles have disappeared. By reproducing the effervescence, the sound is deadened as before. The same experiment may be made with effervescing malt liquors, and with still more effect by putting a piece of sponge, or a little wool or tow, into a tumbler of water. The cause of the result obtained by M. Chladni is that the glass and the contained liquid, in order to give a musical tone, must vibrate regularly in unison as a system; and, if any considerable part of a system is unsusceptible of regular vibration, the whole must be so. Baron Humboldt has employed this interesting experiment to illustrate and explain the phenomenon of distant sounds being more distinctly heard during the night,

NIGHT-MARE. Comfortable and undisturbed sleep is one of the greatest enjoyments of life; and, as the

brain sympathises more or less with every part of the body, it may be considered a strong proof of health. On the contrary, any interruption in this blessing, independent of mental perturbation, may be considered as a decisive proof of some deviation from health. The slightest disorder of the system may be frequently perceived by paying attention to the state of mind during sleep, particularly to the nature of dreams. This may be demonstrated by attending carefully to the state of the rest of persons on the approach of fever or any epidemic disease, when no sign of any disorder of the system is apparent. Frightful dreams, however, though sometimes the forerunners of dangerous and fatal diseases, not unfrequently occur when the disturbance of the system is comparatively trifling, as they accompany almost every derangement of the digestive organs. Children, whose digestive organs are particularly liable to derangement, are often the subjects of frightful dreams and night-mare. There are many people who frequently rise in the morning even more wearied and weak, both in mind and body, than when they retired to their couch; and, indeed, to whom sleep is an object of terror rather than comfort, and who in vain seek for relief from the ordinary means suggested by medical men. Mr. Waller, a surgeon in the royal navy, has written on the treatment of night-mare. He observes, "To those persons who are only occasionally subject to, and who are generally most alarmed at it, as the disease comes upon them unexpectedly, and without their being able to assign any cause for it, it appears difficult to apply a remedy, as the mischief is generally over before they are aware of its approach. A little attention, however, to the state of the digestive organs will generally point out to them that it was connected with indigestion, flatulence, or costiveness, or perhaps all these together; frequently it is the consequence of having eaten some particular kind of food, which experience shows always to disagree with the stomach. An old writer on medical subjects observes that 'he who wishes to know what night-mare is, let him eat chestnuts before going to sleep, and drink after them feculent wine.' I have found by experience in the West Indies that eating a particular fruit, called the Alligator pear, would at any time in the *day* produce *night*-mare. This is a pulpy fruit, which, when cut into, resembles a custard, and is frequently spread upon bread and eaten instead of butter, whence it has obtained among military men the name of *subaltern's butter*, and it is frequently no contemptible substitute for fresh butter. I used frequently to eat it beat up with the juice of Seville oranges and sugar, in which case its effects are almost instantaneous. So great a propensity to sleep came upon me that I could not resist the temptation, though well aware of the consequences, so that I generally kept some person by me to awake me as soon as the night-mare came on, which was always in the course of a few minutes. I have frequently shown this experiment to my medical friends. The articles most likely to produce night-mare I conceive to be cucumbers, nuts, apples, and all such things as produce flatulence. Whenever a person has discovered the offending article, it is certainly prudent to abstain from it, more especially in the evening. If, however, that state of stomach and bowels which gives rise to night-mare should be perceived, there will be just reason to apprehend that it will occur, and it will be advisable to have recourse to some preventive. The fit of night-mare does not always immediately follow the eating any improper food, but sometimes several days elapse before its attack. In this case it is easier to foresee and consequently to prevent it. The signs by which its approach may be known are unusual drowsiness, disagreeable dreams, and disturbed sleep, with wind in the stomach and bowels. In this case I would recommend immediate recourse to the carbonate of soda, of which ten grains may be taken mixed with three drachms of the compound tincture of cardamoms. The bowels should be opened by small doses of magnesia and rhubarb mixed in peppermint water. Intemperance of every kind is hurtful, but nothing is more productive of this disease than drinking *bad wine;* of eatables, those which are most prejudicial, are fat and greasy meats, most vegetables, fruits, and pastry. These ought to be avoided, or eaten with caution. The same thing may be said of salt meats, for which dyspeptic patients have frequently a predilection, but which are not on that account less noxious. Moderate exercise contributes in a superior degree to promote the digestion of the food, and prevent the formation of flatulence; to those, however, who are necessarily confined to a sedentary occupation, I would recommend particularly to avoid applying to study, or any other sedentary occupation, immediately after eating. If a strong propensity to sleep should occur after dinner, it will be certainly better to indulge it a little, as the process of digestion frequently goes on much better during sleep than when awake. What has been said with respect to night-mare will apply equally to all other kinds of disturbed sleep. They originate from the same cause, and will be removed by the same remedies."

NIGHTSHADE. This plant has been found of great use in the healing art. The deadly nightshade is a perennial plant, with a herbaceous stem, which is indigenous both in mountainous and woody situations in this country, and often cultivated in gardens. The whole plant is poisonous, and the berries, from their beautiful appearance, have sometimes proved fatal to children. The symptoms excited are, dryness of the mouth, trembling of the tongue, very distressing thirst, difficulty of swallowing, fruitless efforts to vomit, and great anxiety about the præcordia. Delirium then comes on, with gnashing of the teeth, and convulsions. The pupil remains dilated, and is not sensible even to the stimulus of light. The face becomes tumid, and of a dark red colour. The jaws are frequently locked. Inflammation attacks the œsophagus, stomach, and intestines, sometimes extending to the mesentery, lungs, and liver, accompanied with violent pains in the abdomen. The stomach is very insensible to stimulus, and the peristaltic motion of the intestines is destroyed. General relaxation, palsy, especially of the lower extremities, convulsions, vertigo, blindness, coma, and death succeed. The body soon putrefies, swells, and becomes marked with livid spots; blood flows from the nose, mouth, and ears, and the stench is insufferable. On dissection the blood is found to be fluid, the intestines are inflated and inflamed, or eroded and gangrenous. The best method of cure is to excite vomiting as soon as possible, by emetics, and tickling the fauces; to evacuate the bowels by purgatives and glysters; and to give largely vinegar, honey, milk, and oil. In some children who recovered by this

treatment, the delirium was succeeded by a profound stupor, accompanied with subsultus tendinum; the face and hands became pale and cold, and the pulse small, hard, and quick. Their recovery was slow, and the blindness continued a considerable time, but at last went off. Yet this virulent poison, under proper management, may become an excellent remedy. Besides its narcotic power, it promotes all the excretions: but its exhibition requires the greatest caution; for it is apt, when continued for any length of time, even in small doses, to cause dryness and tension of the throat and neighbouring parts, vertigo, dimness of sight, and even temporary blindness. When any of these symptoms occur, its use must be suspended for some time, and afterwards resumed in smaller doses.

Deadly nightshade has been employed; 1. In several febrile diseases: in obstinate intermittents, and in the plague. 2. In inflammations: the gout. 3. In comatose diseases: in palsy, and loss of speech from apoplexy. 4. In spasmodic diseases: in epilepsy, chincough, hydrophobia, melancholy, and mania. 5. In cachectic affections: in dropsies, and obstinate jaundice. 6. In local diseases: in amaurosis, ophthalmia, and cancer.

Deadly nightshade is best employed in substance, beginning with a very small dose of the powdered leaves or root, such as the fourth or eighth part of a grain for children, and one grain for adults, to be repeated daily, and gradually increased. In hydrophobia, Dr. Munch gave the powdered root every second morning, to the extent of from one to five grains to children, and fourteen or fifteen grains to adults.

The watery infusion is also a powerful remedy. One scruple of the dried leaves is infused in ten ounces of warm water, and strained after cooling. At first two ounces of this may be given daily to adults, and gradually increased, until the tension of the throat shows that it would be imprudent to go further.

The watery extract is not a judicious preparation.

Externally, the powdered leaves are applied as a narcotic to diminish pain, and to cancerous and ill-conditioned sores.

Nilometer, an instrument used amongst the ancients to measure the height of the water of the river Nile, at the period of its overflowing. The nilometer is said, by several Arabian writers, to have been first erected for this purpose by Joseph, during his reign in Egypt. It was sixteen cubits in height. As all the riches and prosperity of Egypt depended on the overflowing of this river, the inhabitants were in the habit of supplicating Serapis when they examined the nilometer.

The most rational and consistent account, however, which we have of the nilometer, is given by the celebrated traveller Bruce. "On the point of the island of Rhode, between Geyah and Cairo, near the middle of the river, is a round tower enclosing a neat well or cistern lined with marble. The bottom of this well is on the same level with the bottom of the Nile, which has free access to it through a large opening like an embrasure. In the middle of the well rises a thin column of eight faces of blue and white marble, of which the foot is on the same plane with the bottom of the river. This pillar is divided into twenty divisions called pecks, of twenty-two inches each. Of these pecks the two lowermost are left without any division, to stand for the quantity of sludge which the water deposits there. Two pecks are then divided, on the right-hand, into twenty-four digits each; then on the left four pecks are divided into twenty-four digits; then on the right, four; and on the left another four: again, four on the right, which completes the number of eighteen pecks from the first division marked on the pillar, each peck being twenty-two inches. Thus the whole, marked and unmarked, amounts to something more than thirty-six feet English.

"On the night of St. John, when, by the falling of the dew, they perceive the rain-water from Ethiopia mixed with the Nile at Cairo, they begin to announce the elevation of the river, having then five pecks of water marked on the nilometer and two unmarked for the sludge, of which they take no notice. Their first proclamation, supposing the Nile to have risen twelve digits, is twelve from six, or it wants twelve digits to be six pecks. When it has risen three more, it is nine from six; and so on, till the whole eighteen be filled, when all the land of Egypt is fit for cultivation. Several canals are then opened, which convey the water into the desert, and prevent any further overflowing of the fields; for, were the inundation suffered to go on, it would not drain soon enough to fit the land for tillage: and to guard against this mischief is the principal use of the nilometer, though the Turkish government makes it an engine of taxation. From time immemorial the Egyptians paid, as tribute, a certain proportion of the fruit of the ground; and this was anciently ascertained by the elevation of the water on the nilometer, and by the mensuration of the land actually overflowed. But the Saracen government, and afterwards the Turkish, taxed the people by the elevation alone of the water, without attending to its course over the country or the extent of the land actually overflowed."

Nitre. This salt is, under certain circumstances, formed spontaneously at the surface of the soil; it is thus procured in India, whence the nitre we use is imported. In some countries of Europe, the production of it is favoured by artificial arrangements. Vegetable and animal substances, with an intermixture of old plaster, mortar, or other forms of carbonate of lime, are put into ditches lined with clay, and covered with sheds to protect them from the rain, while the air is admitted. They are turned up occasionally, and at the end of a few months, when washed with water, afford nitrates of potash and lime. A quantity of wood-ashes is added to the solution, the potash of which decomposes the nitrate of lime, and increases the product of nitrate of potash; this salt is obtained in crystals by evaporation, and is purified from a portion of muriate of soda and other saline matter which adheres to it, by repeated solutions and crystallizations.

The nitre does not pre-exist in these materials, and is therefore obviously formed in the process. As an intermixture of animal and vegetable matter, the presence of carbonate of lime, and the admission of the atmospheric air, are all necessary, it is probable that the nitrogen of the animal matter combines with the oxygen of the air, and perhaps with a portion of the oxygen of the vegetable matter, and forms the acid, the carbonate of lime favouring this combination by the resulting affinity exerted by the lime, and attracting the acid as it is formed: the vegetable matter moderates the decomposition of the animal substances, and prevents them from running into that

putrefaction by which the nitrogen is spent in the formation of ammonia; it may further afford the potash, which is the base of the nitre, though it has also been supposed that a part of this is formed in the process. A certain degree of humidity favours the mutual actions whence these combinations arise, and diffuses more equally through the materials the nitrous salts.

Nitre crystallizes in six-sided prisms, bevelled at the extremities; its taste is cool; it is soluble in seven parts of water at 60°, a production of cold attending its solution, and in an equal quantity of boiling water. It melts easily: if the heat be raised, a partial decomposition of the acid takes place, and oxygen gas is expelled; and at the temperature of ignition the decomposition is more complete, and oxygen and nitrogen gases are disengaged.

From its facility of decomposition by heat, nitre produces deflagration, when heated with inflammable bodies. It is from this property that it is employed as the principal ingredient in the composition of gunpowder, which consists of seventy-five parts of it by weight with sixteen of charcoal and nine of sulphur. These ingredients are thoroughly mixed by continued trituration, a small quantity of water being added to favour this; the paste into which the composition is at length brought is granulated by pressing it through a sieve, and the grains, after they are dry, are rounded and glazed by friction from agitation. The deflagration of the gunpowder, when an ignited spark falls on it, is owing to the rapid communication of the oxygen to the sulphur and the charcoal, the sulphur in particular being easily inflamed; and its great expansive force depends on the sudden extrication of the aërial products. Sulphurous acid and carbonic acid are formed by the oxygenation of the sulphur and charcoal, and nitrogen by the decomposition of the acid, probably with watery vapour, the elasticity of these being much increased by the caloric rendered sensible.

Nitric Acid.—This acid, which can be extracted without much difficulty from common nitre and sulphuric acid, has been long known to chemists, and in a diluted state has been used in the chemical arts under the name of aquafortis. Priestley observed its partial decomposition, and its reproduction from the union of nitric oxide (the product of that decomposition) with oxygen. Cavendish discovered its ultimate composition, and proved that nitrogen is its base. This was done by a very simple experiment,—taking the electric spark for a considerable time in atmospheric air, confined in a tube. The volume was diminished, an acid was produced, and this acid was found to be nitric. When a portion of oxygen gas was added to the air, and the electric spark continued sufficiently long, the disappearance of the whole was nearly complete; and a similar result was obtained from submitting to experiment a mixture of oxygen and nitrogen gases. In all these cases, the electric spark establishes the combination of the gravitating matter of the two gases; and the principal peculiarities which attend this combination are the slowness with which it takes place, and its not being accompanied by any sensible extrication of heat and light.

Analysis likewise establishes the composition of nitric acid. If it be passed through an ignited glass or earthen tube, it is resolved into oxygen and nitrogen gases; its saline compounds exposed to a red heat afford the same elements; and its oxygen can be abstracted by inflammable substances, its nitrogen being evolved, either pure or retaining a portion of oxygen combined with it, which by further operations may be abstracted.

It has been found difficult to determine with accuracy the proportions in which its elements combine, and in particular to reconcile them with those of the other nitrous compounds, conformably to the usual laws of definite proportions. Those assigned by Cavendish were 72.2 of oxygen and 27.8 of nitrogen by weight. Davy stated them not far different from these, at 70.5 of oxygen and 29.5 of nitrogen. The latter are not far from the proportions of 100 of nitrogen and 200 of oxygen by measure. Gay-Lussac, judging from the composition of nitric oxide and the quantity of oxygen with which he found it to combine to form nitric acid, states the proportions at 100 of nitrogen and 250 of oxygen by measure.

Nitric acid is obtained from the decomposition of nitre, a salt in which it exists combined with potash, and the process usually followed is that by the medium of sulphuric acid. Two parts of nitre in coarse powder are put into a retort, and rather more than one part of sulphuric acid is poured upon it, the retort being placed in a sand-bath, and connected with a large receiver. A moderate heat is applied to produce distillation; towards the end it is gradually raised, and is continued as long as any acid is produced. The sulphuric acid combines with the potash of the nitre, and disengages the nitric acid, this decomposition being aided by the greater volatility of the nitric acid. The nitric acid, however, when disengaged, is also partially decomposed; losing a little of its oxygen, a portion of it passes to the state of nitric oxide, and this being absorbed by the acid which distils over gives it a yellow colour, more or less deep, or converts it into nitrous acid. This decomposition appears to arise in a great measure from the action of the high temperature, and hence it takes place principally towards the end of the distillation. The addition of more sulphuric acid than is strictly necessary to neutralize the potash of the nitre is useful, partly from the quantity aiding its affinity, and partly by affording water to preserve the constitution of the nitric acid.

In consequence of this partial decomposition, an additional process is requisite to obtain nitric acid. The coloured acid is exposed to a gentle heat, applied by a water-bath; the nitric oxide holding a portion of nitric acid combined with it is expelled, and the acid becomes nearly colourless; or, what succeeds more completely, the nitrous acid is distilled from a little oxide of manganese, which, imparting to it oxygen, converts it into nitric.

Nitric acid is colourless and transparent; it emits white vapours having a peculiar odour. It has all the acid properties, tastes sour even when much diluted, reddens the vegetable colours, and neutralizes the properties of the alkalies and earths. Its specific gravity is 1.55 at 60°. In this state it contains a quantity of combined water, equal, according to Kirwan and Dalton, to 26, according to Dr. Wollaston to 25.1 in 100 parts. The presence of water is essential to the acid in its insulated state, as it can neither be formed nor can it be disengaged from its saline combinations without water be supplied to it.

This acid freezes by cold, the facility of congelation varying considerably, according to its state of

concentration: if it is highly concentrated, or if, on the other hand, it is much diluted, it freezes with more difficulty than when of intermediate strength. It is volatilized by heat; but its volatility is also much influenced by its state of concentration; the highest boiling point is that of the acid at the specific gravity of 1.42; it boils at 248°; if either stronger or weaker than this, it boils at a lower temperature. This, too, is the only acid which rises unchanged by boiling, a weaker acid becoming stronger, and a stronger acid than this becoming weaker, as it boils. At a higher heat the acid is partially decomposed. A partial decomposition of it is also effected by light; oxygen is expelled, and it passes to the state of nitrous acid.

Nitric acid has a considerable affinity to water: it attracts it from the atmosphere, and it combines with it in every proportion. In consequence of this affinity, too, it acts with energy on ice and snow, liquefying them rapidly, and producing intense cold.

The affinity between the elements of this acid not being strong, it is decomposed by metallic and inflammable bodies, which attract its oxygen partially or completely; and, in consequence of this facility with which it yields oxygen, it acts with much energy on these substances.

It combines with the alkalies, earths, and metallic oxides, forming salts, denominated nitrates. The generic characters of these are a cool penetrating taste, affording oxygen gas at a high temperature, and deflagrating with inflammable bodies at the temperature of ignition. They are all soluble in water, and crystallizable. The individual nitrates will be considered under their respective bases. (See Oxide, Nitric.)

Nitrogen.—This gas has already been examined under the name of Azote, and we must now confine ourselves to a few facts connected with its combination with *iodine* and *chlorine*. Nitrogen combines with chlorine and iodine to form two very remarkable compounds. The first of these, the *chlorine of nitrogen*, is formed by the action of chlorine on some salt of ammonia. Its formation is owing to the decomposition of ammonia (a compound of nitrogen and hydrogen) by chlorine: the hydrogen of the ammonia unites with chlorine and forms muriatic acid, while the nitrogen of the ammonia, being presented in its nascent state to chlorine dissolved in the solution, enters into combination with it. The chloride of nitrogen is formed gradually, when a glass receiver filled with chlorine gas is inverted over a bowl containing a solution of muriate of ammonia, and falls in little globules through the fluid to the bottom of the dish, whence it is withdrawn with the utmost care by means of a glass syringe. On being ejected into a metallic mortar, or leaden dish, containing a little volatile oil, or phosphorus in small pieces, it detonates with extreme violence. Its specific gravity is 1.653: it is not congealed by the intense cold produced by a mixture of snow and salt, may be distilled at 160° Fahr., but explodes at a temperature between 200° and 212°. It consists of chlorine 144, or four proportions; nitrogen fourteen, or one proportion.

Iodide of nitrogen. From the weak affinity that exists between iodine and nitrogen, these substances cannot be made to unite directly; but, when iodine is put into a solution of ammonia, the alkali is decomposed, its elements unite with different portions of iodine, and thus cause the formation of hydriodic acid and iodide of nitrogen. The latter subsides in the form of a dark powder, which is characterized, like chloride of nitrogen, by its explosive property. It detonates violently as soon as it is dried, and slight pressure while it is moist produces a similar effect. Heat and light are emitted during the explosion, and iodine and nitrogen are set free. It consists of one proportional of nitrogen to three of iodine.

With regard to the nature of nitrogen there has been, and still exists, a considerable diversity of opinion. Berzelius has inferred, from speculations connected with the doctrine of definite proportions, that it is a compound of oxygen with an unknown base, to which he has given the name of *nitricum*, and has fixed the proportions at 44.32 of base and 55.68 of oxygen; others, on the contrary, have affirmed, as a consequence of this doctrine, that nitrogen can contain no oxygen—a proof of the little value to be attached to such speculations. The strongest arguments for the compound nature of nitrogen are derived from its slight tendency to combination, and from its being found abundantly in the organs of animals which feed on substances that do not contain it. Its uses in the economy of the globe are little understood. One thing however is certain, that it serves to dilute the oxygen of the atmosphere, and without it we could not employ the ordinary materials of combustion.

Nitro-Muriatic Acid is formed by mixing muriatic acid and nitric acid. This compound has some peculiar properties, among which is that of dissolving gold with facility, from which it received from the alchemists the name of *aqua regia*. One part of muriatic acid is mixed with two parts of nitric; during their combination the formation of oxymuriatic acid is indicated by its odour, nitric oxide gas is disengaged, and a portion of it is retained in the liquid, giving it a dark orange colour. It is concluded, therefore, that in the mutual action of these acids part of the nitric acid is decomposed, its oxygen is transferred to the muriatic, and to the oxymuriatic acid thus formed the peculiar chemical powers of the compound have been ascribed. It appears, however, to be chiefly a compound of nitric and muriatic acids; and its energetic action on the metals seems to be owing to the latter acid by a disposing or resulting affinity promoting the decomposition of the former, favouring therefore the communication from it of oxygen to the metal, with which in its oxidated state it then combines. It is employed in some of the processes of assaying.

Nitrous Acid.—This name is given to the yellow acid obtained by the usual process of decomposing nitre by sulphuric acid; and it owes its yellow colour to the presence of a portion of nitric oxide. When this is disengaged by a moderate heat, it becomes colourless: and, if nitric oxide is transmitted through it in this state, it regains its colour.

It appears to follow from these facts that there is no acid of determinate composition to which the name nitrous can be properly applied. What is called such is nitric acid holding nitric oxide dissolved: and the quantity of this may be variable, and even indefinite, between the minimum and maximum. According to the quantity communicated, the colour is deeper. From a portion not exceeding 1.2 of nitric oxide by weight in 100 parts, a pale yellow colour is communicated; this, as the quantity is increased, passes through shades of bright yel-

low to dark orange, in which the proportion amounts to about 5.5; beyond this an olive colour, and then a bright green, verging into blue, are obtained; and, if the transmission of the nitric oxide gas be continued longer, it communicates its elasticity to the liquid acid, and the whole rises in very dense. red, suffocating vapours.

Some chemists have, however, assumed the existence of an acid of determinate composition, and have in particular given this name to the compound in which the largest proportion of nitric oxide gas is condensed by oxygen gas. It is obtained by admitting oxygen gas to nitric oxide gas, when the latter is kept in excess: a dense red-coloured vapour is formed.

Nitrous acid vapour, formed by the combination of nitric oxide and oxygen gases, is of a deep red colour, extremely suffocating; its specific gravity is 1.457, air being 1000; it is rapidly absorbed by water, forming a solution of a green colour. It acts on inflammables, and, in particular, sustains the combustion of phosphorus.

The common liquid nitrous acid must, if these views be correct, be a mixture of these acids of a specific composition in various proportions with probably more or less water. It is more or less coloured according to the quantity of nitric oxide; its specific gravity is also diminished, a pale acid of 1.52, when converted into yellow acid, becoming nearly of the specific gravity of 1.51. The acid obtained by distillation from nitre and sulphuric acid is usually of a pale yellow colour: but, if the heat has been raised very high towards the end of the process, it is of a deeper colour; and, if any inflammable matter has been contained in the materials, it is of a dark orange red. The colours which the acid assumes from this impregnation of nitric oxide are likewise dependent on its state with regard to dilution. If the dark orange-coloured acid be mixed with water, the different shades are produced; with a large quantity of water, blue; with more acid, olive, and bright green. These colours are not permanent, the oxygen loosely dissolved in the water, or imbibed from the atmosphere, oxygenating the nitric oxide, and bringing the whole to the state of nitric acid.

Nitrous acid in its relations to other chemical agents is similar to nitric acid. It oxidizes in the same manner and with the same phenomena, in inflammable bodies and metals, and combines with the metallic oxides. These combinations are indeed merely those of the nitric acid, as the nitrous oxide is disengaged during the process.

The compounds of nitrous acid with the alkalies or earths can scarcely be obtained by direct combination; for, when it is added, the greater part of the nitric oxide is expelled. They are usually obtained by an indirect mode, pointed out by Scheele, that of exposing a nitrate to such a heat as partially decomposes the nitric acid, and expels part of its oxygen. The remaining acid with a portion of nitric oxide exists in combination with the alkaline base, forming the salts which have been named nitrites. They are easily decomposed, and give out nitrous acid vapour on the affusion of an acid. On exposure to the atmosphere, they absorb oxygen, and return to the state of nitrates. (See OXIDE, NITROUS.)

NODES, in *astronomy;* the two points where the orbit of a planet intersects the ecliptic. These nodes are constantly changing their places.

NORIA, a hydraulic machine used in Spain. It consists of a vertical wheel of twenty feet diameter, on the circumference of which are fixed a number of little boxes or square buckets, for the purpose of raising the water out of the well, communicating with the canal below, and emptying it in a reservoir above, placed by the side of the wheel. The buckets have a lateral orifice to receive and to discharge the water. The axis of this wheel is embraced by four small beams, crossing each other at right angles, tapering at the extremities, and forming eight small arms. This wheel is near the centre of the horse-walk, contiguous to the vertical axis, into the top of which the horse-beam is fixed; but near the bottom it is embraced by four small beams, forming eight arms, similar to those above described, on the axis of the water-wheel. As the mule which they use goes round, these horizontal arms, supplying the place of cogs, take hold, each in succession, of those arms which are fixed on the axis of the water-wheel, and keep it in rotation.

This machine raises a great quantity of water; but it has two defects: the first is, that part of the water runs out of the buckets and falls back into the well after it has been raised nearly to the level of the reservoir: the second is, that a considerable proportion of the water to be discharged is raised higher than the reservoir, and falls into it only at the moment when the bucket is at the highest point of the circle, and ready to descend.

Both these defects are occasionally remedied by leaving the square buckets open at one end, making them swing on a pivot fixed a little above their centre of gravity, and placing the trough of the reservoir in such a position as to stop their progress whilst perpendicular, make them turn upon their pivot, and so discharge their contents.

From the reservoir the water is conveyed by channels to every part of the garden; these have divisions and subdivisions or beds, some large, others very small, separated from each other by little channels, into which a boy, with his shovel or his hoe, directs the water, first into the most distant trenches, and successively to all the rest, till all. the beds and trenches have been either covered or filled with water.

Mr. Townsend, from whom we take the above account, states that by the aid of this machine the inhabitants every morning draw as much water from the well as will serve through the day, and in the evening distribute it to every quarter according to the nature of their crops. The reservoirs into which they raise the water are about twenty, thirty, or even forty feet square, and three feet high above the surface of the ground, with a stone cope on the wall, declining to the water, for the women to wash and beat their clothes upon.

Our limits preclude us from following Mr. Townsend further in the description of a particular noria used at Barcelona, which he conceives to be the original chain-pump, or at least its parent. He compares it with similar instruments, and shows its advantages and disadvantages.

NORTH; one of the four cardinal points of the world, being that point of the horizon which is directly opposite to the sun at its meridian. The north wind is generally accompanied with a considerable decrease of temperature. It sometimes blows with almost irresistible fury; and is often mentioned by the classic authors under the name of *Boreas.*

Nose; that prominence on the face which is the organ of scent. The ancients seem to have had an aversion to small noses, and the Romans esteemed above all the aquiline nose, which Pliny termed, by way of distinction, *royal*. It is thus that Ælian has described that of Aspasia, and Philostratus those of Achilles and of Paris. According to Plutarch, Cyrus had the same; and on this account the Persians are said to have admired noses of this shape. But aquiline noses were reckoned beautiful only when the curve was gentle and almost insensible, in contradistinction to such as were decidedly crooked, resembling the beak of a parrot. The Grecians, indeed, generally speaking, seem to have held a straight line from the forehead, or rather slightly inclined, to be the *beau idéal* with respect to this feature; and accordingly we find it in their best statues, &c.

Nosology, in *medicine;* that science which treats of the systematic arrangement and classification of diseases.

Notation, in *arithmetic*, is the method of expressing, by means of certain signs, any proposed number or quantity. In the modern analysis, *notation* implies a method of representing any operation belonging to this science; and the judicious and ingenious selection of proper symbols forms not the least important part of it. The success of a great mathematical operation depends much upon this point, and the science itself has sometimes made a new advance by the invention of new and more manageable symbols. In the common scale of notation, every number is expressed by the ten characters 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, the first nine of which represent different numbers of units, and denote various values according to the place which they occupy.

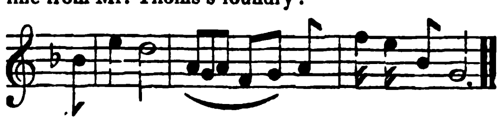
Notes, in *music;* the signs for tones. Even in the most remote antiquity, certain letters of the alphabet were used as signs for musical tones. According to some, the Hebrews made use of accents for this purpose, as the modern Greeks still do. The Greeks used different signs for vocal and instrumental music; and, as they had not yet conceived the idea of using the octave to express, by means of a prefixed key, a number of the most diversified tones in a similar manner, they must have required a great number of notes (said to have amounted to 990; half for vocal tones, half for instruments). As they used the alphabetical signs for notes, it became necessary to employ the same letter in different positions (inclining, inverted, &c.); thus F signified, in different positions, seven different tones. Accents, also, were used, partly by themselves, partly added to letters.

If a poem was to be sung, the letters which signified the instrumental tone were placed first; under these the letters for the voice; and under these the words. As the syllables of the Greek language have mostly a natural and distinct quantity (i. e. duration of time), the Greek notes were not required to show the time, and generally could be restricted to height, depth, and nature of tone. In the case of the syllables called common (short and long), there was a liability to mistake, and they were therefore marked with A if long and with B if short. The fifteen chief tones of the Greek system were first reduced to seven by pope Gregory I. towards the end of the sixth century, and marked with the first seven letters of the Roman alphabet; so that the capitals were used for the first voice, the small letters for the higher octave, and the double letters for the highest octave.

Parallel lines were soon invented, on which the letters were written. These were used until the happy idea was conceived of substituting for letters points with five lines, the points and rhombuses being placed as well between the lines as on them. This invention is generally ascribed to Guido of Arezzo. According to some, it was known even in the tenth century. The letters which had been formerly used as notes now became clefs. Still the sign for the duration of a tone was wanting. The way of marking it was invented, according to some, by a German of Cologne, of the name of Franco, who lived towards the end of the eleventh century. Others ascribe the invention, or at least the improvement, to John de Murs (Jean de Moeurs, or Meurs.) The *diminutio*, or division of one note into others of less value (for instance, the division of a fourth into two eighths), and the use of running notes, were invented first by Jean Mouton, chapel-master to king Francis I., in the sixteenth century. Since Rousseau, the designating of notes by ciphers has been repeatedly proposed, and adopted with great success in elementary schools; but, in other respects, the old way of writing notes—one of the most ingenious contrivances ever produced, which seems to have given to Leibnitz even the idea of a *pasigraphy*, or system of universal writing—has kept its ground.

As to printing notes, two periods are distinguished—the first when notes were printed by plates, the second by movable types. The first plates used for this purpose were of wood, and the oldest known are of 1473. Then the printing of notes by copper-plates was invented. The cheaper way of printing from tin plates, in which the notes are punched with steel punches, did not become common till the middle of the last century.

As to the second period, the inventor is uncertain. Some consider Ottavio Pistrucci, in the beginning of the sixteenth century, as such. James Panlecque (born at Chaulne, in Picardy, 1573), a celebrated type-founder at Paris, where he died 1648, probably introduced the printing of notes from types into France. Yet the art of printing with them remained very imperfect, until the well-known typographer Breitkopf, at Leipsic, carried the process, in 1755, to such perfection that he may fairly be called the second inventor. The printing of music with movable types has now attained so high a degree of excellence as to equal that which is printed from tin or pewter plates, in proof of which we give a line from Mr. Thoms's foundry:



Tauchnitz, of Leipsic, first stereotyped notes. The process of lithography is used at present.

Great musicians can sometimes compose with the pen in their hand, and without the aid of the piano. They hear all the music in their soul, as a picture stands, with all its hues and proportions, before the mental eye of an artist, prior to his touching the canvass. Many persons, however, who play well extempore, are by no means able to compose on paper; and for them a machine would be convenient which could accompany the player's motions, and write the notes with a rapidity equal to that of his performance. The first idea of such a machine was given in

the *Philosophical Transactions,* in 1747 (No. 483), as the invention of an English clergyman of the name of Creed; yet the practicability of this idea was not sufficiently shown. In 1748, a Mr. Unger, burgomaster of Eimbeck, had the same idea without knowing of Creed's communication; and, in 1752, the academy of sciences at Berlin approved of his suggestions; but nothing was done until a member of the academy, M. Selzer, induced a mechanic, Hohlfeld, to construct such a machine from an imperfect description of Unger's plan. In the *Nouveaux Mémoires de l'Académie royale des Sciences et des Belles-lettres à Berlin,* of 1771, is a description of this machine. It consists of two cylinders, from one of which paper rolls off, while it is rolled round the other, during which time the keys move corresponding pencils, which write the note on the paper. Not much use, however, has been made of the machine.

November; the ninth month of the Roman year. In our calendar it forms the eleventh.

Noyau; a cordial. The word is French, and is derived from the use of the kernels of apricots, nectarines, and peaches, in flavouring the liqueur of which it is the name. The use of them in too large quantities has sometimes made the liqueur poisonous, as prussic acid may be extracted from them. The other ingredients are French brandy, prunes, celery, bitter almonds, a little essence of orange-peel, essence of lemon-peel, and rose-water. It is used like the other liqueurs.

Number.—Number is either abstract or applicate: abstract when referred to things in general, without attending to their particular properties; and applicate when considered as the number of a particular sort of things, as yards, trees, &c. When particular things are mentioned, there is always something more considered than barely their numbers; so that what is true of number in the abstract, or when nothing but the number of things is considered, will not be true when the question is limited to particular things: for instance, the number two is less than three; yet two yards is a greater quantity than three inches, because regard must be had to their different natures as well as number, whenever things of a different species are considered; for, though we can compare the number of such things abstractedly, yet we cannot compare them in any applicate sense. And this difference is necessary to be considered, because upon it the true sense, and the possibility or impossibility, of some questions depend. Number is unlimited in respect of increase; because we can never conceive a number so great but still there is a greater. However, in respect of decrease, it is limited; unity being the first and least number, below which therefore it cannot descend, except by subdivision into decimal or other parts, which may also be extended infinitely, at least in idea, if not in fact; for we cannot conceive any particle of matter so small but that it may be supposed capable of being rendered still smaller by division and subdivision.

Numerator of a Fraction; that number which stands above the line, and shows how many parts the fraction consists of, as the *denominator* represents the number of parts into which the unit is supposed to be divided.

Numismatics is the name of the science which has for its object the study of coins and medals, principally those struck by the ancient Greeks and Romans. The name of *coins* is given to the pieces of metal on which the public authority has impressed different marks to indicate their weight and value, to make them a convenient medium of exchange. By the word *medals*, when used in reference to modern times, is understood pieces of metal similar to coins, not intended as means of exchange, but struck and distributed in memory of some important event. The name of *medals*, however, is sometimes given to all pieces of money which have remained from ancient times.

The parts of a coin or medal are the two sides; 1. the obverse side, face, or head, which contains a portrait of the person at whose command or in whose honour it was struck, or other figures relating to him. This portrait consists either of the head alone, or the bust, or of a half or full-length figure. 2. The reverse contains mythological, allegorical, or other figures. The words around the border form the legend; those in the middle the inscription. Neither of these was originally placed on coins: the latter is frequently merely a monogram. The lower part of the coin, which is separated by a line from the figures, or the inscription, is the basis, or *exergue*, and contains subsidiary matter, as the date, the place where the piece was struck, &c.

Numismatics has the same divisions as history. Ancient numismatics extends to the extinction of the empire of the West; the numismatics of the middle ages commence with Charlemagne; modern numismatics with the revival of learning. The pieces of metal used first as money were rude and shapeless, with some mark to indicate at once their weight and value. Ancient writers even mention money of leather among the Carthaginians, Spartans, and Romans. Money of wood is also mentioned among the Romans; as also of shells, which are still used by some African tribes. But gold, silver, and copper, have been and are the ordinary materials of money. The form of money is round, oval, square, triangular, or long, as were at first the *oboli*. The study of medals is indispensable to archæology, and to a thorough acquaintance with the fine arts. They indicate the names of provinces and cities, determine their position, and present pictures of many celebrated places. They fix the period of events, determine, sometimes, their character, and enable us to trace the series of kings. They enable us to learn the different metallurgical processes, the different alloys, the mode of gilding and plating practised by the ancients, the metals which they used, their weights and measures, their different modes of reckoning, the names and titles of the various magistrates and princes, and also their portraits, the different divinities, with their attributes and titles, the utensils and the ceremonies of their worship, the costume of the priests—in fine, every thing which relates to usages, civil, military, and religious. Medals also serve to acquaint us with the history of art. They contain representations of several celebrated works of antiquity, as the Hercules Farnese, and the Venus of Cnidus. Like gems and statues, they enable us to trace the epochs of different styles of art, to ascertain its progress among the most civilized nations, and its condition among the rude. Medals are of great assistance to philology, and the explanation of the ancient classics. The ancient medals were struck or cast. Some were first cast, and then struck.

The first coins of Rome, and the other cities of Italy, must have been cast: the hammer could not

have produced so bold a relief. The copper coins of Egypt were cast. The right of coining money has always been one of the privileges which rulers have confined to themselves. The free cities possessed the right of inscribing their names on coins. The cities subject to kings sometimes obtained permission to strike money in their own name, but most frequently were required to add the name or image of the king to whom they were subject. The medals of the Parthians and Phœnicians offer many examples of this sort. Rome, under the republic, allowed no individual the right to coin money; no magistrate was to put his image thereon, though, sometimes, this honour was allowed by a particular decree of the senate.

We can count among the numismatic countries only those into which the Greeks and the Romans carried the use of money. The people in the most northern part of Europe had no money, nor had those of Asia, which extended most to the east, and those of Africa, at a distance from the Mediterranean. Weight should be the standard of the value of money; and many volumes have been written on the value of coins and their weight. The difficulties, however, have not been entirely cleared up, because the same terms have always been employed without regard to difference of time. In the code of Justinian complaints are made of the indefiniteness of these expressions in donations. The difficulty is increased by the difference of weight in the coins of different cities, and by our ignorance of the value of gold and silver compared with that of bronze at different periods. The coins preserved from antiquity are much more numerous than those which we possess from the period of the middle ages, in the proportion of 100 to one.

Medals are sometimes dug up singly, or in small numbers, where they appear to have been thrown by accident; but the principal stores are found in tombs, or in places where fear, avarice, or superstition had deposited them. Millin thinks that the number of extant medals from ancient times may amount to 70,000. Till the third century, the faces on medals were represented in profile. In the coins of the lower empire, on the contrary, we see Gothic front faces filling the whole field of medals. The moderns have employed both modes. The ancients gave more relief to the figure. The art of coining has flourished much in Spain. That country was deprived of the privilege of coining in the time of Caligula. The most ancient Spanish medals are of silver; their form is rude, the style of the design barbarous. The numerous cities which existed in ancient Gaul, before its conquest by the Romans, fabricated money of gold, silver, and copper. The execution of some of them is excellent, but the greatest part are barbarous. No medals are known of Britain, with the exception of some struck by some of the Augustuses, towards the decline of the Roman empire; and the same may be said of Germany. The medals of some of the Italian cities bear the character of Greek art, and are excellent. The medals of these cities are numerous, as the Romans permitted their inhabitants to coin money long after having subjected them. Greece and Asia Minor present many fine and curious medals. The coins of the kings of Macedon are the most ancient of any yet discovered bearing portraits; and Alexander I., who commenced his reign about 500 years B. C., is the earliest monarch whose medals have yet been found. Then succeed the sovereigns who reigned in Sicily, Caria, Cyprus, Heraclea, and Pontus. Afterwards comes the series of kings of Egypt, Syria, the Cimmerian Bosphorus, Thrace, Parthia, Armenia, Damascus, Cappadocia, Paphlagonia, Pergamos, Galatia, Cilicia, Sparta, Pæonia, Epirus, Illyricum, Gaul, and the Alps. This series reaches from the era of Alexander the Great to the Christian era, comprising a period of about 330 years. This must be accounted the third medallic series of ancient monarchs; and the fourth and last descends to the fourth century, including some of the kings of Thrace, of Bosphorus, and Parthia, with those of Comagene, Edessa, or Osrhoene, Mauritania, and Judea. A perfect and distinct series is formed by the Roman emperors, from Julius Cæsar to the Gothic destruction of the empire, and, indeed, still later. The Grecian medals claim that place in a cabinet, from their antiquity, which their workmanship might ensure to them independently of that adventitious consideration.

It is observed by Pinkerton that an immense number of the medals of cities, which, from their character, we must judge to be of the highest antiquity, have a surprising strength, beauty, and relief, in their impressions. About the time of Alexander the Great, however, this art appears to have attained its highest perfection. The coins of Alexander and his father exceed all that were ever executed, if we except those of Sicily, Magna Græcia, and the ancient ones of Asia Minor. Sicilian medals are famous for their workmanship, even from Gelo's time. The coins of the Syrian kings, successors to Alexander, almost equal his own in beauty. But adequate judges are constrained to confine their high praises of the Greek mint to those coins struck before the subjection of Greece to the Roman empire. The Roman coins, considered as medals in a cabinet, may be resolved into two great divisions, the consular and imperial. The consular coins seldom or never bore the names or titles of consuls till towards the close of the republic; nevertheless they are not improperly called *consular*, because they were struck in the consular times of Rome. These have also been denominated "coins of families," and are arranged according to the names inscribed on them. The brass consular coins are rather uninteresting, consisting chiefly of large, unwieldy pieces, with types of great similarity. Few of them have any imagery or symbol.

Gold was first coined at Rome, sixty-two years after the application of the mint to silver. The general gold coin is the *aureus*. The consular coins, whose number is estimated at 200 in brass and 2000 in silver, extend not to above 100 in gold, most of which are curious. The name of *imperial* medals is applied specifically to those struck after the conclusion of the republican era of Rome down to the fall of the Roman empire. Caius Julius Cæsar was the first Roman who obtained permission to put his figure upon medals. The triumvirs had each his set of medals. The medals struck after the death and apotheosis of Augustus bear the title *Divus Augustus*. With Constantine commences the series of medals of the emperors of the East or of Constantinople. The series of imperial medals concludes with those of Michael IX. The colonial medals had sometimes Greek, sometimes even Punic, legends; but those with Latin only are far more numerous. Some of these coins are elegant; but they are for the most part rude and uninteresting. They begin with Julius and

Antony, and occur only in brass. Most of the gold consular coins are of great beauty and high value. They are also very rare.

The coins of the middle ages embrace the *bracteates*, &c., which after the dissolution of the Roman empire were circulated in the newly-formed European states.

The science of numismatics seems to have been entirely unknown to the ancients. It does not appear from any ancient works that any value was set upon coins as curiosities by the collectors of works of art in the times of Augustus and the Antonines, though there were at that time series of coins of cities, some of which have come down to us, and attract attention on account of their antiquity and the beauty of their execution. Such are the coins of Sybaris and the cities of Magna Græcia, which, with their independence, lost the right of coinage. This disregard is more remarkable because gems, which are so nearly allied to them, were in high esteem; but in the fifteenth, and particularly in the middle of the sixteenth century, princes, and private individuals, in Italy, France, and Germany, rivalled each other in zeal for collecting these remains of antiquity, at first principally with a view of obtaining portraits of the chief characters of Roman history. Learned treatises soon succeeded these first collections, in which the chief attention had been paid to striking impressions.

The earliest treatise upon numismatics was published by a Spaniard, Antonio Agostino, in 1577, in his dialogues, which have been translated into all languages. Jac. and Octav. Strada, by works illustrated with plates, drew the attention of the great and the rich to this subject. Wolfgang Lazius, physician to Ferdinand I., made use of coins for the illustration of history. Fulvio Orsini, and Ad. Occo, a physician at Augsburg, applied themselves to the study of the Roman family and imperial coins: and it is to be regretted that the latter restricted himself so much in his enquiries; for his process, with respect to chronological arrangement, was confessedly good. Hub. Goltz, the son of a painter of Wurtzburg, is particularly worthy of mention, as the first who paid much attention to Grecian coins; but there is a want of accuracy in the writers of that period which renders a great part of their labours useless. Goltz was at once a draughtsman and an engraver, but suffered himself to introduce so much of his own invention into his engravings of coins that they are liable to suspicion in many cases where they may have been correct. Meanwhile the art of imitating the genuine antique coins began to be practised. At first, without any intention of deceiving, but merely to facilitate the study, the skilful die-cutters, Cavino, Belli, &c., at Padua, Parma, and Vicenza, made imitations of ancient coins; but these imitations were afterwards passed off for genuine, and soon became an article of trade, which has continued to this day.

The great number of counterfeit coins deterred many, during the period which now commenced, from the study of numismatics; at least it lessened the taste for this study, always difficult on account of the learned apparatus necessary; but the researches into separate departments of the science became more extensive, and the works of Vaillant, Spanheim, J. J. Gessner, Pellerin, not to mention numerous others, who have applied immense stores of learning to the illustration and explanation of numismatics, are well worthy of attention, though they are not to be implicitly trusted. The materials had now so much increased, by the accumulation of newly-discovered pieces (Vaillant visited the east several times; Pellerin added to the Parisian cabinet alone 33,000 ancient coins), that a critical selection and arrangement of the genuine became doubly necessary, in order to facilitate a general survey of them. Joseph Eckhel undertook this task with success, and, by a strict geographical and chronological method, introduced so much order into this science that great light was shed upon many obscure points of history and archæology. His system was first practically applied by himself to the arrangement of the cabinet at Vienna, and afterwards presented in an improved form in his great work, *Doctrina Numorum Veterum* (Vienna, 1792—98, 8 vols., 4to.), to which all later researches can only be considered as additions or improvements.

The coins of the middle ages, which have from time to time been brought to light, are now sought for with zeal. By pursuing the same method with the modern as with the ancient coins, arranging them in a strictly chronological order, they have been made to shed light upon subjects which manuscripts had left unexplained.

NUTATION of the axis of the earth. By a slight study of the *precession* of the *equinoxes* the reasons will be seen why the axis of the globe undergoes annually a change of position of about 50″, on account of the irregularity in the attractions of the sun and moon, occasioned by the spheroidal form of the earth. Of these 50″, 30″ are, on an average, referrible to the attraction of the moon. But she cannot produce this effect regularly, on account of her own change of position; and there result from these changes not only inequalities in the quantity of the precession of the equinoxes, but also a small motion or *nutation* in the axis of the earth, or in the plane of the equator, in consequence of which the stars appear sometimes to approach the equator, at other times to recede from it, varying from their mean place about 9½ seconds. This apparent change in the declination of the stars was first discovered by observation by Bradley, and the physical causes of it were explained by D'Alembert and others. It is obvious that a change in the position of the moon towards the earth must produce a change in the attraction of the moon upon the spheroidal part of the earth. Now this position is affected considerably by the change in the situation of the moon's nodes, which are subjected to an annual motion of about 18°, completing a revolution round the heavens in about eighteen or nineteen years. In consequence of this the position of the moon's orbit to the equator can vary 10°, and the change in the attraction of the moon on the spheroidal part of the earth, arising from this change of inclination, produces the nutation of 9½ seconds, the period of which is about eighteen or nineteen years. The precession and nutation alter the right ascensions, declinations, and longitudes of the heavenly bodies; the latitudes remain unchanged. D'Alembert (in his *Recherches sur la Précession des Equinoxes et sur la Nutation* (Paris, 1749, 4to.), and Laplace (*Mécanique Celeste*), have succeeded, by analysis, in reducing all these intricate phenomena to the law of gravity with the most complete success, and the corrections calculated thereupon, and contained in the astronomical tables, agree most perfectly with observations.

NUTMEG. The use of this fruit for culinary purposes is well known, as it has become an article of commerce in every part of the civilized world. With the East Indians it is likewise employed as a masticatory. It does not, however, appear to have been very anciently known, at least among Europeans; for the Greeks and Romans have left no account of it, and it is first mentioned by the early Arabian writers. The tree that produces it is a native of the Molucca islands, and is remarkable for the beauty of its foliage. It attains the height of about thirty feet, and the branches are disposed four or five together, almost in circles, forming a rounded and very dense summit. The fruit is a drupe, about as large as a peach, smooth externally, and yellow when it arrives at maturity: the outer envelope is fleshy, and opens at the summit into two valves, disclosing the scarlet mace, which forms the second envelope: the mace is a fleshy fibrous membrane, having a reticulated appearance, which turns yellow with age, and becomes brittle when dry; the third envelope is thin, hard, and blackish-brown; the nut, or, more properly, kernel, consists of a very firm, white, oily substance, penetrated with numerous irregular branching veins. The tree constantly bears flowers and fruits of all ages, and its leaves fall so insensibly that the loss is not perceived. About nine months are required to bring the fruit to maturity. Mace is very commonly employed as a culinary spice, and resembles the nutmeg in taste and odour, but is more pungent and bitter.

For a long time, the Dutch had the monopoly of the commerce in nutmegs; but, about the year 1770, it was introduced into the Isle of France, and thence passed into Surinam, the West Indies, and other parts of tropical America. During the last year, rather more than 250,000 lbs. of nutmegs were imported into this country, of which only 160,000 lbs. were retained for home consumption, and the rest exported.

NUTRITION; the process by which living creatures repair the loss which attrition and other causes are continually making in the animal frame. In young persons the nutritive juices not only serve to repair the waste, but also to supply the new materials essential to the growth of the individual.

Buffon, in order to account for nutrition, supposes the body of an animal or vegetable to be a kind of mould, in which the matter necessary to its nutrition is modelled and assimilated to the whole. But (continues he) of what nature is this matter which an animal or vegetable assimilates to its own substance? What power is it that communicates to this matter the activity and motion necessary to penetrate this mould? and, if such a force exist, must it not be by the same force that the internal mould itself is reproduced?

As to the first question, he supposes that there exists in nature an infinite number of living organical parts, and that all organized bodies consist of such organical parts; that their production costs nature nothing, since their existence is constant and invariable; so that the matter which the animal or vegetable assimilates to its substance is an organical matter of the same nature with that of the animal or vegetable, which consequently may augment its volume without changing its form or altering the quality of the substance in the mould.

As to the second question, "there exist," says he, "in nature certain powers, as that of gravity, that have no affinity with the external qualities of the body, but act upon the most intimate parts, and penetrate them throughout, and which can never fall under the observation of our senses."

And, as to the third question, he answers that "the internal mould itself is reproduced, not only by a similar power, but it is plain that it is the very same power that causes the unfolding and reproduction thereof; for it is sufficient," proceeds he, "that in an organized body that unfolds itself there be some part similar to the whole, in order that this part may one day become itself an organized body, altogether like that of which it is actually a part."

We may next examine the practical part of this subject, and show the comparative nutritive properties of different species of food, and the effects of cookery in increasing or diminishing its power of sustaining animal life.

Dr. Paris thus compares the relative advantages of an *animal* and *vegetable* diet with reference to nutrition. "As every description of food," says he, "whether derived from the animal or vegetable kingdom, is converted into blood, it may be inferred that the ultimate effects of all aliments must be the same, and that the several species can differ from each other only in the quantity of nutriment they afford, in the comparative degree of stimulus they impart to the organs through which they pass, and in the proportion of vital energy they require for their assimilation. Were the degree of excitement which attends the digestion of a meal commensurate with the labour imposed upon the organs which perform it, less irritation and heat would attend the digestion of animal than of vegetable food; for, in the one case, the aliment already possesses a composition analogous to that of the structure which it is designed to supply, and requires little more than division and depuration; whereas, in the other, a complicated series of decompositions and recompositions must be effected before the matter can be animalized or assimilated to the body. But the digestive fever, if we may be allowed the use of that expression, and the complexity of the alimentary changes, would appear in every case to bear an inverse relation to each other. This must depend upon the fact of animal food affording a more highly animalized chyle, or a greater proportion of that principle which is essentially nutritive, as well as upon the immediate stimulus which the alimentary nerves receive from its contact. In hot countries therefore, or during the heats of summer, we are instinctively led to prefer vegetable food, and we accordingly find that the inhabitants of tropical climates select a diet of this description. The Brahmins in India, and the people of the Canary Islands, Brasils, &c., live almost entirely on herbage, grains, and roots; while those of the north use little besides animal food.' On account of the superior nutritive powers of animal matter, it is equally evident that the degree of bodily exertion or exercise sustained by a person should not be overlooked in an attempt to adjust the proportion in which animal and vegetable food should be mixed. Persons of sedentary habits are oppressed and ultimately become diseased from the excess of nutriment which a full diet of animal food occasions: such a condition, by some process not understood, is best corrected by acescent vegetables. It is well known that artisans and labourers in the confined manufactories of large towns suffer considerably in their health whenever a

failure occurs in the crops of common fruits; this fact was remarkably striking in the years 1804 and 1805. Young children and growing youths generally thrive upon a generous diet of animal food; the excess of nutritive matter is consumed in the developement of the body, and, if properly digested, imparts strength without repletion. Adults and old persons comparatively require but a small proportion of aliment, unless the nutritive movement be accelerated by violent exercise and hard labour.

Those who advocate the exclusive value of animal food, and deny the utility of its admixture with vegetable matter, adduce in proof of their system the rude health and Herculean strength of our hardy ancestors. The British aborigines, when first visited by the Romans, certainly do not appear to have been conversant with the cultivation of the ground; and according to the early writers, Cæsar, Strabo, Diodorus Siculus, and others, their principal subsistence was on flesh and milk; but, before any valid conclusion can be deduced from this circumstance, the habits of the people must be compared with those of their descendants. The history of later times will furnish us with a satisfactory answer to those who deny the necessity of vegetable aliment. We learn from the *London Bills of Mortality* that scurvy raged to such an excess in the sixteenth century as to have occasioned considerable ravages; at this period the art of gardening had not long been introduced. It appears that the most common articles of the kitchen garden, such as cabbages, were not cultivated in England until the reign of Henry VIII.; indeed, we are told that his queen, Catherine of Arragon, could not procure a salad until a gardener was sent for from the Netherlands to raise it. Since the change thus happily introduced into our diet, the ravages of the scurvy are unknown. It follows, then, that in our climate a diet of animal food cannot, with safety, be exclusively employed. It is too highly stimulant; the springs of life are urged on too fast; and disease necessarily follows. There may, nevertheless, exist certain states of the system which require such a preternatural stimulus; and the physician may, therefore, confine his patient to an animal regimen with as much propriety as he would prescribe opium, or any other remedy. By a parity of reasoning, the exclusive use of vegetable food may be shown to be inconsistent with the acknowledged principles of dietetics, and to be incapable of conveying a nourishment sufficiently stimulating for the active exertions which belong to our present civilized condition. At the same time it must be allowed that an adherence to vegetable diet is usually productive of far less evil than that which follows the use of an exclusively animal regimen.

Dr. Paris quotes some curious experiments made by M. Majendie to ascertain the relative quantities of azote (nitrogen) yielded by animal and vegetable food. He took a small dog of three year's old, fat, and in good health, and put it to feed upon sugar alone, and gave it distilled water to drink: it had as much as it chose of both. It appeared very well in this way of living for the first seven or eight days; it was brisk, active, ate eagerly, and drank in its usual manner. In the second week it began to get thin, although its appetite continued good, and it took about six or eight ounces of sugar in twenty-four hours. Its alvine excretions were neither frequent nor copious; that of the urine was very abundant. In the third week its leanness increased, its strength diminished, the animal lost its liveliness, and its appetite declined. At this period there was developed upon one eye, and then on the other, as mall ulceration on the centre of the transparent cornea; it increased very quickly, and in a few days it was more than a line in diameter; its depth increased in the same proportion; the cornea was very soon entirely perforated, and the humours of the eye ran out. This singular phenomenon was accompanied with an abundant secretion of the glands of the eyelids. It, however, became weaker and weaker, was unable to stand, and, though the animal ate from three to four ounces of sugar per day, it became so weak that it could neither chew nor swallow: for the same reason every other motion was impossible. It expired the thirty-second day of the experiment. M. Majendie opened the animal with every possible precaution. He found a total want of fat; the muscles were reduced more than five-sixths of their ordinary size; the stomach and intestines were also much diminished in volume, and strongly contracted. The gall and urinary bladders were distended by their proper fluids, which M. Chevreul was called upon to examine. That distinguished chemist found in them nearly all the characters which belong to the urine and bile of herbivorous animals; that is, that the urine instead of being acid, as it is in carnivorous animals, was sensibly alkaline, and did not present any trace of uric acid, nor of phosphate. The bile contained a considerable portion of picromel, a character considered as peculiar to the bile of the ox, and, in general, to that of herbivorous animals. The excrements were also examined by M. Chevreul, and were found to contain very little azote, whereas they usually furnish a considerable quantity.

M. Majendie considered that such results required to be verified by new experiments: he accordingly repeated them on other dogs, but always with the same conclusions. He therefore considered it proved that sugar, by itself, is incapable of supporting dogs. He afterwards proceeded to enquire whether other substances, nonazotised, but generally considered as nutritive, would be attended with the same consequences, which was found to be the fact.

The character and amount of cookery which food undergoes materially affects its nutritive properties, and we cannot do better than quote Dr. Paris's observations on this branch of our subject. "By *cookery*," he says, "alimentary substances undergo a two-fold change; their principles are chemically modified, and their textures mechanically changed. The extent and nature, however, of these changes, will greatly depend on the manner in which heat has been applied to them; and, if we enquire into the culinary history of different countries, we shall trace its connexion with the fuel most accessible to them. This fact readily explains the prevalence of the peculiar species of cookery which distinguishes the French table, and which has no reference, as some have imagined, to the dietetic theory, or superior refinement, of the inhabitants."

By boiling, according to this author, the principles not properly soluble are rendered softer, more pulpy, and consequently easier of digestion; but the meat, at the same time, is deprived of some of its nutritive properties by the removal of a portion of its soluble constituents. The albumen and

gelatine are also acted upon, the former being solidified and the latter converted into a gelatinous substance. If, therefore, our meat be boiled too long or too fast, we shall obtain, where the albumen predominates (as in beef), a hard and indigestible mass, like an over-boiled egg; or where the gelatine predominates, as in young meats, such as veal, a gelatinous substance equally injurious to the digestive organs.

Young and viscid food, therefore, as veal, chickens, &c., is more wholesome when roasted than when boiled, and is easily digested. Dr. Prout has very justly remarked that the boiling temperature is too high for a great many of the processes of cookery, and that a lower temperature and a greater time, or a species of infusion, are better adapted for most of them. This is notorious with substances intended to be stewed, which, even in the cookery books, are directed to be boiled slowly (that is, not at all), and for a considerable time. The ignorance and prejudice existing on these points is very great, and combated with great difficulty; yet, when we take into account their importance, and how intimately they are connected with health, they will be found to deserve no small share of our attention. The loss occasioned by boiling partly depends upon the melting of the fat, but chiefly on the solution of the gelatine and osmazone: mutton generally loses about one-fifth, and beef about one-fourth, of its original weight. Boiling is particularly applicable to vegetables, rendering them more soluble in the stomach, and depriving them of a considerable quantity of air, so injurious to weak stomachs. But, even in this case, the operation may be carried to an injurious extent; thus, potatoes are frequently boiled to a dry insipid powder, instead of being preserved in that state in which the parts of which they are composed are rendered soft and gelatinous, so as to retain their shape, yet be very easily separated. On the other hand, the cabbage tribe, and carrots, are frequently not boiled long enough, in which state they are highly indigestible. In conducting this process, it is necessary to pay some attention to the quality of the water employed; thus, mutton boiled in hard water is more tender and juicy than when soft water is used; while vegetables, on the contrary, are rendered harder and less digestible when boiled in hard water.

By *roasting*, the fibrin is corrugated, the albumen coagulated, and the fat liquefied. As the operation proceeds, the surface becomes first brown and then scorched; and the tendinous parts are rendered soft and gluey. Care should always be taken that the meat be not overdone: nor ought it to be under-dressed; for, although in such a state it may contain more nutriment, yet it will be less digestible, on account of the density of its texture. This fact has been satisfactorily proved by the experiments of Spallanzani; and Mr. Hunter observes "that boiled, and roasted, and even putrid meat, are easier of digestion than raw." Animal matter loses more by roasting than by boiling: it has been stated above that in this latter process mutton loses one-fifth, and beef one-fourth; but, by roasting, these meats lose about one-third of their weight. In roasting, the loss arises from the melting out of the fat, and the evaporating of the water; but the nutritious matter remains condensed in the cooked solid; whereas, in boiling, the gelatine is partly abstracted. Roast meats are, therefore, more nutritive than boiled.

A memoir presented to the French Academy, by M. Donné, having thrown some doubts upon the wholesomeness of gelatine, M. Darcet made the following summary:—Butchers' meat contains per 100 lbs. at a medium:

Dry meat	24
Water	64
Bones	15
Total	103

Bones contain per 100:

Earthy matter	60
Gelatine	30
Fat	10
	100

Thus the fifteen parts of bones in butchers' meat may furnish six parts of pure animal substance, and therefore 100 lbs of meat, which commonly yield but twenty-four of alimentary matter, may furnish thirty pounds, if care be taken to extract the whole. It is obvious, therefore, that four head of cattle may supply as much nutriment as is now obtained by five. (See PAPIN'S DIGESTER.)

NUX VOMICA, a flat, compressed, round, and poisonous fruit, about the breadth of a shilling, brought from the East Indies. Its surface is not much corrugated; and its texture is firm like horn, and of a pale greyish-brown colour. It is said to be used as a specific against the bite of a species of water-snake. It is considerably bitter, and has been used in doses from five to ten grains twice a day or so, in intermittents, particularly quartans, and in contagious dysentery. The *strychnus Ignatii* is a tree of the same kind, producing a guard-like fruit, the seeds of which are improperly called St. Ignatius's beans. These, as also the woods or roots of some such trees, called *lignum colubrinum*, or snakewood, are very narcotic bitters, like the *nux vomica*.

NYCTALOPIA; an affection of the sight, in which the patient is blind in the daylight, but sees very well at night.

With respect to the causes of the complaint, Dr. Hillary observes that it proceeds from too great a tenderness and sensibility of the iris and retina. M. Lassus thinks the causes may be of different kinds. For instance, he says that if there were a small opacity, like a point, exactly opposite the pupil or centre of the crystalline lens, the pupil, contracting in the open daylight, would stop the entrance of the rays of light into the eye, and a day blindness arise, which would be diminished by the expansion of the pupil in the shade. Here, the cure would depend upon the removal of the opacity.

Persons whose pupils do not move freely, but remain much dilated, and do not sufficiently contract in light situations, are also affected with nyctalopia; for so large a quantity of the rays of light pass into their eyes that it serves rather to destroy than assist vision. Such persons see tolerably well, and better than the preceding class of patients, in a darkish place, and they ought to wear green spectacles in the day-time, in order to weaken the impression of the rays of light. When a person is shut up a long while in a dark place, the pupils become habitually dilated, and, if he expose himself suddenly and incautiously to a strong light, the eyesight may be destroyed. This is more particularly the case when experiments with the oxy-hydrogen blow-pipe are made.

OAK.—This tree is valuable both for its timber and the application of its bark to the useful arts. The oak grows wild in Britain, and flowers in April. The superior excellence of its wood for ship-building has rendered its cultivation an object of national concern. Duhamel made a series of experiments to ascertain the strength of oak wood. He placed a piece of oak, 9.6 inches deep, 10.6 inches in breadth, upon two supports 24½ inches apart; when a weight of 8193 lbs. was suspended to the middle, it was bent in the middle 3.7 inches. The piece broke with a weight of 9613 lbs., when it was found to have been faulty.

Another piece of oak, but sound, 12.2 inches deep, 10.6 inches thick, and placed on supports at the same distance apart as at the first trial, with a weight of 8193 lbs., bent 2.6 inches, and broke with a weight of 19,666 lbs. which was placed in the middle.

A piece of sound oak, 13.8 inches deep, 12.8 inches thick, and placed on supports 24½ feet apart, was bent one inch in the middle with a weight of 8198 lbs.

A piece of English oak 7 feet long, 2 inches broad, and 2 inches deep, bent 1.27 inches with a weight of 200 lbs.

A piece of Canadian oak of the same dimensions bent 1.07 inch with a weight of 225 lbs.

A piece of old ship timber, 2½ feet long, 1 inch broad, and 1 inch deep, bent ½ inch with a weight of 127 lbs.

The oak bark is a material much used in tanning. It was formerly thought to be extremely useful in vegetation. One load of oak bark, laid in a heap and rotted, after the tanners have used it for dressing of leather, will do more service to stiffen cold land (says Mr. Mills, in his treatise on husbandry) than two loads of the richest dung; but this has been controverted.

M. Vauquelin discovered a remarkable chemical difference between the bark and nut-galls, the latter precipitating tartrate of antimony and infusion of cinchona, which are not acted on by the former. Oak bark is a strong astringent, and is recommended in hæmorrhages, alvine fluxes, and other preternatural or immoderate secretions. In these it is sometimes attended with good effects. But it is by no means capable of being employed as a substitute, in every instance, for Peruvian bark, as some have asserted; and, indeed, it is so difficultly reduced to a sufficiently fine powder, that it can scarcely be given internally, in substance.

Olivier has, in his *Travels in the Ottoman Empire*, given us an accurate botanical description of the oak which produces the gall-nut, and which, he says, was till then unknown to botanists. It is scattered through all Asia Minor, from the Bosphorus to Syria, and from the shore of the Archipelago to the frontiers of Persia. It has a crooked stem, and seldom reaches the height of six feet. It oftener has the appearance of a shrub than of a small tree. The gall-nuts come at the shoots of the young bough, and are produced by the puncture of *diplolepis gallæ tinctoriæ* to deposit an egg. They acquire from four to twelve lines in diameter, and are generally round and covered with tuberosities. They are in perfection when they have acquired their full size and weight, but before the insect has pierced them, after which they get a brighter colour and lose some of their weight. The galls first picked are laid apart, and are known under the name of *yorli*, and in commerce are called black and green galls. Those gathered later are called white galls, and are very inferior in value. In commerce they occur of different sizes, smooth or knotty on the surface, of a whitish, reddish, or blackish colour, and generally penetrated with a small hole. Internally they consist of a spongy, but hard, more or less brown substance, and they have a very rough astringent taste. The best galls are of a blackish-grey, or yellow colour, heavy, and tuberculated on the surface. Neumann got from 960 grains of coarsely powdered galls 840 watery extract, and afterwards only 4 alcoholic; and, inversely, 760 alcoholic, and 80 watery. But the most minute analysis is that of Sir H. Davy, who found that 500 grains of good Aleppo galls gave, by lixiviating them until their soluble matters were taken up, and evaporating the solution slowly, 185 grains of solid matter, which, when examined by analysis, appeared to consist of,

Tannin	130
Mucilage, and matter rendered insoluble by evaporation	12
Gallic acid, and a little extractive matter	31
Remainder, calcareous earth and saline matter	12

From some experiments by Dr. Duncan, he is disposed to think that Sir H. Davy has under-rated the tannin of nut-galls; for, by simple repeated infusions in hot water, the residuum of 500 grains in one experiment amounted only to 158, and in another only to 136 grains. The quantity of tannin estimated in Sir H. Davy's way amounted in the first to 220 grains, and in the second to 256. The great difference in these results from Sir H. Davy's must be ascribed to some differences in the galls themselves, or in the mode of operation. A saturated decoction of galls, on cooling, deposits a copious pale yellow precipitate, which seems to be purer tannin than what can be got by any other process; but it still requires and deserves a more minute examination. In Dr. Duncan's experiments, a very weak infusion of nut-galls was precipitated by sulphuric acid, lime-water, sub-carbonate of potass, acetate of lead, sulphate of copper, nitrate of silver, sulphate of iron, tartrate of antimony, nitrate of mercury, infusion of officinal cinchona, and solution of gelatine; it was not precipitated by nitrous acid, ammonia, sulphate of zinc, muriate of mercury, infusion of quassia, or infusion of saffron. To what principles these precipitates are owing remains still to be ascertained. Vauquelin justly observes that the infusion of nut-galls and of cinchona agree in precipitating both gelatine and tartrate of antimony, but that they precipitate each other. Another fact, equally curious, occurred: a mutually saturated mixture of the infusions of nut-galls and cinchona still precipitates gelatine; but these infusions, separately saturated by gelatine, do not act on each other. Hence it appears that the action of these infusions on each other depends on principles contained in each, compatible with the presence of tannin, but re-acting on each other, and that gelatine precipitates these principles along with the tannin. Sir H. Davy has concluded that tannin and gelatine unite in fixed proportions, viz. 46 of tannin with 54 gelatine: were this correct, it would very much facilitate the analysis of astringents. A twelve hours' infusion of 500

grains of nut-galls in twelve ounces of water, precipitated successively with equal quantities of solution of gelatine, containing each twenty-four grains, gave precipitates weighing 98, 64, 48, and 36 grains: hence, if we suppose the whole gelatine used to be contained in each precipitate, these consisted of 24 grains of gelatine, and 74, 40, 24, and 12 grains of tannin: so that, from the weight of the precipitate alone, we cannot estimate the tannin. Dr. Bostock drew the same conclusions from a set of experiments which he made. It has been generally asserted that the precipitate of tannin and gelatine is insoluble in water, either cold or hot; but Dr. Duncan found that in boiling water it not only became soft and viscid, but a certain portion was dissolved, which separated again when the solution cooled.

Oakum; the substance into which old ropes are reduced when they are untwisted, loosened, and drawn asunder. It is principally used in calking the seams, tree-nails and bends of a ship, for stopping or preventing leaks.

Oar; a long piece of timber, flat at one end, and round or square at the other, used to make a vessel advance upon the water. The flat part, which is dipped into the water, is called the *blade*, and that which is within the board is termed the *loom*, whose extremity, being small enough to be grasped by the rowers, is called the *handle*. To push the boat or vessel forwards by means of this instrument, the rowers turn their backs forwards, and, dipping the blade of the oar in the water, pull the handle forward, so that the blade, at the same time, may move aft in the water. But, since the blade cannot be so moved without striking the water, this impulsion is the same as if the water were to strike the blade from the stern towards the head: the vessel is therefore necessarily moved according to the direction. Hence it follows that she will advance with the greater rapidity, by as much as the oar strikes the water more forcibly; consequently, an oar acts upon the side of a boat or vessel like a lever of the second class, whose fulcrum is the station upon which the oar rests on the boat's gunwale.

Oat.—The meal of this grain is nutritious, and in some countries forms an important article of food; but the bread made of it is rather indifferent in quality, and somewhat bitter. Beer is made from this grain in Poland; and it is, besides, distilled to procure ardent spirits. Oats are the best food for horses, and for this purpose are principally cultivated. They are also recommended as a good winter fodder for sheep, a handful to be given daily.

Obelisk, in *architecture*; a truncated, quadrangular, and slender pyramid. Obelisks are of very great antiquity, and appear to have been first raised to transmit to posterity precepts of philosophy, which were cut in hieroglyphical characters; afterwards they were used to immortalise the great actions of heroes, and the memory of eminent persons. The first obelisk mentioned in history was that of Ramasus king of Egypt, in the time of the Trojan war, which was forty cubits high. Phius, another king of Egypt, raised one of fifty-five cubits; and Ptolemy Philadelphus another of eighty-eight cubits, in memory of Arsinoë. Augustus erected one at Rome in the Campus Martius, which served to mark the hours of an horizontal dial drawn on the pavement. They were called by the Egyptian priests the fingers of the sun, because they were made in Egypt also to serve as styles or gnomons to mark the hours on the ground. The Arabs still call them Pharaoh's needles; whence the Italian *agvglia*, and the French *aiguilles*. One of the most common and frequent situations in which obelisks were erected was the space before a temple. At Luxor are still to be found two very fine obelisks: they are shown in the accompanying view.

These obelisks are about 100 feet in height, and are each composed of a single block of granite, from the quarries of Elephantine.

The Romans, in the plenitude of their power and splendour, removed many of these relics from their original situations into Italy. When that majestic empire was over-run by the barbarians most of these noble monuments were thrown down, defaced, or demolished. The exhumations made by the decree of pope Sextus V. brought to light four of them, which were repaired by his architect, Fontana. Since that period several others have been dug up. Several obelisks have likewise been preserved at Constantinople, the most celebrated of which stood in that part of the hippodrome denominated Media Spina. On the four sides of the base of this noble monument were sculptured a variety of subjects; the bassi-relievi of the northern side have been published by Spon. At Catana, in Sicily, fragments have been discovered of two Egyptian obelisks, most probably conveyed thither by the Romans. One has been set up again, presenting a curious appearance, from its having eight faces.

On the north side of Penrith, in Cumberland, in the church-yard, are two square obelisks of a single stone each, eleven or twelve feet high, about twelve inches diameter, and twelve by eight at the sides; the highest about eighteen inches diameter, with something like a transverse piece, and mortised into a round base. They are fourteen feet asunder, and between them is a grave enclosed between four semicircular stones of the unequal lengths of five, six, four and a half, and two feet high, having on the outsides rude carving, and the tops notched. This is called the Giant's Grave, and ascribed to Sir Ewan

Cæsarius, who is said to have been as tall as one of the columns, and capable of stretching his arms from one to the other.

Object-Glass. See Telescope.

Oblate (flattened or shortened); having its axis shorter than its middle diameter, being formed by the rotation of an ellipse about the shorter axis. The earth is an oblate spheroid, the polar diameter being shorter than the equatorial diameter in the proportion of 331 to 332; i. e. the polar diameter is 7898 miles, and the equatorial diameter 7924 miles.

Obligato, in *music*, is used of those voices or instruments which are indispensable to the just performance of a piece. An instrument may be *obligato* throughout a piece, in which case the piece is called a *concerto* for such an instrument; or an instrument may become now and then *obligato*, when these passages are called *obligato* or *solo* passages. All instruments can be used *obligato*, except, perhaps, the double bass: this is excepted partly because solo players are very rare on this instrument, partly because the solo voice would be too deep for being duly supported by other instruments; it is therefore used more properly for the basis of harmony. There are some musicians, however, who play solos on the double bass.

Obolus; a Grecian coin of silver or copper, the sixth part of a drachm, about 10⅓ pence in value. In early times, instead of money, were used little pointed pieces of iron or of copper. Six of these filled the hand, and made a drachm. The same name was afterwards given to a small silver coin. The Greeks placed an obolus in the mouth of the dead, to pay Charon for their passage over the Styx. In weight, the obolus is likewise the sixth part of a drachm; the latter coin, however, is not always of the same value.

Observatory; a place destined for observing the heavenly bodies, being generally a building erected on some eminence, covered with a terrace for making astronomical observations. The more celebrated observatories are—

The *Greenwich* observatory, built in 1676, by order of Charles II., at the solicitation of Sir Jonas Moore and Sir Christopher Wren; and furnished with the most accurate instruments.

Tycho Brahe's observatory, in the little island Ween, or Scarlet Island, between the coasts of Schonen and Zealand in the Baltic. It was erected and furnished with instruments at his own expense, and called by him *Uraniburg*. Here he spent twenty years in observing the stars: the result is his catalogue.

Father Le Compte describes a very magnificent observatory, erected and furnished by the emperor of *China*, in his capital, at the intercession of some Jesuit missionaries, principally father Verbeist, whom he made his chief observer. The instruments are exceedingly large; but the mode of division is less accurate, and the contrivance in some respects less commodious, than that of the Europeans. The chief are, an armillary zodiacal sphere of six feet diameter; an equinoctial sphere of six feet diameter; an azimuthal horizon of six feet diameter; a large quadrant six feet radius; a sextant eight feet radius; and a celestial globe six feet diameter.

The following interesting account of the observatory at *Benares* is taken from a paper in the sixty-seventh volume of the Philosophical Transactions by Sir Robert Barker. "We entered this building," says Sir Robert Barker, "and went up a staircase to the top of a part of it, near the river Ganges, that led to a large terrace, where, to my surprise and satisfaction, I saw a number of instruments yet remaining in the best preservation, stupendously large, immovable from the spot, and built of stone, some of them being upwards of twenty feet in height; and, though they are said to have been erected 200 years before, the gradations and divisions on the several arcs appeared as well cut, and as accurately divided, as if they had been the performance of a modern artist. The execution in the construction of these instruments exhibited a mathematical exactness in the fixing, bearing, and fitting of the several parts, in the necessary and sufficient supports to the very large stones that compose them, and in joining and fastening them into each other by means of lead and iron cramps. The situation of the two large quadrants, whose radius is nine feet two inches, by being at right angles with a gnomon at 25° elevation, are thrown into such an oblique situation as to render them the most difficult, not only to construct of such a magnitude, but to secure in the position for so long a period, and affords a striking instance of the ability of the architect in their construction; for, by the shadow of the gnomon thrown on the quadrants, they do not appear to have altered in the least from their original position; and so true is the line of the gnomon that by applying the eye to a small iron ring, of an inch diameter, at one end, the sight is carried through three others of the same dimensions to the extremity at the other end, distant thirty-eight feet eight inches, without obstruction; such is the firmness and art with which this instrument has been executed. This performance is the more extraordinary when compared with the works of the artificers of Hindostan of this day who are not under the immediate direction of a European mechanic; but arts appear to have declined equally with science in the east.

"Lieutenant Colonel Archibald Campbell, at that time (1777) chief engineer in the East India Company's service at Bengal, a gentleman whose abilities do honour to his profession, made a perspective drawing of the whole apparatus that could be brought within his eye at one view; but I lament he could not represent some very large quadrants, whose radii were about twenty feet, being on the side whence he took his drawing. Their description, however, is that they are exact quarters of circles of different radii, the largest of which I judged to be twenty feet, constructed very exactly on the sides of stone walls built perpendicular, and situated, I suppose, in the meridian of the place: a brass pin is fixed at the centre or angle of the quadrant, from which the brahmin informed me they stretched a wire to the circumference when an observation was to be made; from which it occurred to me that the observer must have moved his eye up or down the circumference by means of a ladder or some such contrivance to raise or lower himself, till he had discovered the altitude of any of the heavenly bodies in their passage over the meridian, so expressed on the arcs of these quadrants; these arcs were very exactly divided into nine large sections; each of these again into ten, making ninety divisions or degrees; and those also into twenty, expressing three minutes each, of about two-tenths of an inch asunder; so that it is probable they had some method of dividing even these into more minute divisions at the time of observation.

"My time would only permit me to take down

the particular dimensions of the most capital instrument, or the greater equinoctial sun-dial, which appears to be an instrument to express solar time by the shadow of a gnomon on two quadrants, one situated to the east and the other to the west of it; and indeed the chief part of their instruments at this place appear to be constructed for the same purpose, except the quadrants, and a brass instrument described hereafter. There is another instrument for the purpose of determining the exact hour of the day by the shadow of a gnomon, which stands perpendicular to, and in the centre of, a flat circular stone, supported in an oblique situation by means of four upright stones and a cross-piece; so that the shadow of the gnomon, which is a perpendicular iron rod, is thrown on the divisions of the circle described on the face of the flat circular stone. There is also a brass circle, about two feet diameter, moving vertically on two pivots between two stone pillars, having an index or hand turning round horizontally on the centre of this circle. This instrument appears to be made for taking the angle of a star at setting or rising, or for taking the azimuth or amplitude of the sun at rising or setting. The use of another instrument I was at a loss to guess. It consists of two circular walls, the outer of which is about forty feet in diameter and eight feet high; the wall within is about half that height, and appears intended for a place to stand in to observe the divisions on the upper circle of the outer wall, rather than for any other purpose; it is divided into 360 degrees, each degree being subdivided into twenty small divisions, the same as the quadrants. There is a door-way to pass into the inner circle, and a pillar in the centre of the same height with the lower circle, having a hole in it, in the centre of both circles, which seems to be a socket for an iron rod to be placed perpendicularly in it. The divisions on these, as well as all the other instruments, will bear a nice examination with a pair of compasses. There is also a smaller equinoctial sun-dial, constructed on the same principle as the large one. This observatory at Benares is said to have been built by the order of the emperor Ackbar; for, as this wise prince endeavoured to improve the arts, so he wished also to recover the sciences of Hindostan, and therefore directed that three such places should be erected, one at Delhi, another at Agra, and the third at Benares. Some doubts have arisen with regard to the certainty of the ancient Brahmins having a knowledge in astronomy, and whether the Persians might not have introduced it into Hindostan when conquered by that people; but these doubts, I think, must vanish when we know that the present Brahmins pronounce, from the records and tables which have been handed to them by their forefathers, the approach of the eclipses of the sun and moon, and regularly as they advance give timely information to the emperor and the princes in whose dominions they reside."

The *Paris* royal observatory was begun in 1667, and finished in 1672. It is 160 feet in front length, 120 broad, and ninety feet high, having a terrace at top, and cellars underneath ninety feet deep. There is said to be neither iron nor wood employed in its construction. Here was not long since an old thermometer of M. de la Hire, which stood always at the same height. The mural quadrant used by La Lande here has been, in imitation of that of Tycho Brahe, transferred to the heavens as a constellation situated between Hercules, Bootes, and the Serpent, as the quadrans muralis, containing forty stars. New rooms and vaults have been added to this building since 1788, as well as a large transit instrument and circle by Ramsden; and three observers were established here by the unfortunate Louis XVI. On the first floor of the west tower is a geographical chart, twenty-seven feet in diameter, traced under the direction of Cassini. The difference in longitude between this and the Greenwich observatory is 2°, 20′, 15″. There are now two fine observatories in Paris.

The *St. Petersburg* observatory, which is one of the most magnificent and well-furnished in Europe, was an erection of the czar Peter I. shortly after his visit to England. It has three stories, and is 130 feet high. M. de l'Isle, according to La Lande, has made a number of excellent observations here. The celebrated observatory at Dublin is described in our article ASTRONOMY.

OCEAN; the great mass of waters which surrounds the land, and which probably extends from pole to pole, covering nearly three quarters of the globe. For the sake of convenience we distinguish different parts of it under the names of *seas, bays, gulfs, sounds*, and even give the name of *ocean* to large portions which are partially divided from each other by the continents; but these divisions are arbitrary. The following classification, adopted by Malte-Brun in his *System of Geopraphy*, has at least the advantage of showing in a striking manner the connection which exists between the great masses of water :—

A. Great Austro-Oriental or South-Eastern Basin.	1. Austral Ocean, or Southern Frozen Ocean (Antarctic Ocean).	Its limits are a line drawn from Cape Horn to the Cape of Good Hope, by Van Diemen's Land, and the south of New Zealand, back to Cape Horn.
	2. Oriental or Pacific Ocean.	*a.* The Great Archipelago (*Oceanica*), comprised between the Austral Ocean, the Marquesas, the Straits of Malacca, and the latitude of Formosa. *b.* The Northern Oriental Ocean, between Asia and North America. *c.* Southern Oriental Ocean, between the Great Archipelago and South America.
	3. Indian Ocean.	
B. The Western Basin, forming a sort of channel between the two continents.	4. Western Ocean.	*a.* Northern Ocean or Frozen Ocean (Arctic Ocean). *b.* Atlantic Ocean, lying between Europe and North America, and extending south to the nearest points of Brazil and Guinea. *c.* The Ethiopic Ocean, between the Atlantic and Austral Oceans.

For a more particular description of the different geographical divisions of the ocean, see the SECOND DIVISION of this work.

It has been calculated that the land of the northern hemisphere is to the sea of the same as 419 to 1000; in the southern hemisphere the proportion is as 129 to 1000. To account for this great disproportion, it has been conjectured that there is a great southern continent surrounding the south pole, but the voyages of navigators have not revealed the existence of such an extent of land. The bed of the ocean presents the same irregularities of aspect as the surface of the land. It is diversified by rocks, mountains, plains, and deep valleys. In some places it has been found impossible to reach the bottom, but the notion that it is any where without a bottom is incompatible with the spherical figure of the earth. The mean depth of the ocean has been shown by Laplace to be about the same as the mean height of the continents and islands above its surface, which does not much exceed 3000 feet. This distance is but a small fraction of the excess of the equatorial over the polar radius, which is about 60,000 feet. The greatest depth that has ever been sounded is 7200 feet (by Scoresby, in 1819). But it is probable that there are deep cavities or valleys in the bed of the ocean corresponding to the elevation of the mountains on the surface of the earth.

A variety of contrivances have been resorted to for the purpose of ascertaining the depth of the sea at a distance from land, and in those situations in which the common lead-line cannot be employed.

The ingenious Dr. Hales, in his *Vegetable Statics* proposed a method of measuring what he termed the *unfathomable depths* of the sea, on the principles by which Dr. Desaguliers contrived an instrument called a sea-gauge, which was tried before the Royal Society, and is described in the *Philosophical Transactions*, No. 405. A more particular description of this instrument by Dr. Hales himself is as follows :—

Suppose an iron tube, or musket barrel, of any length, as fifty inches, having its upper end well closed; if this tube be let down in this position about thirty-three feet into the sea, a column of water of that height is nearly equal to the mean weight of our atmosphere, and consequently, from a known property of the air's elasticity, it will be compressed into half the space it took up before, so that the water will ascend half-way up the tube: and, if the tube be let down thirty-three feet deeper, the air will be compressed into one-third of its first dimensions, and so on one-fourth, one-fifth, one-sixth, &c., the air being constantly compressible in proportion to the incumbent weight; whence, by knowing to what height the water has ascended in the tube, we may readily know to what depth the tube has descended into the sea.

Now to measure the depth of one of these columns of sea-water: the iron tube should be attached by a line, with a weight at its bottom, and allowed to sink about thirty-three feet, which depth in salt water will nearly answer to the weight of the air at the mean height of the barometer; then draw up the tube, and observe how far the water rose. If thirty-three feet of water be equal to one atmosphere, then will the water rise so high as to fill exactly one-half of the tube: but, if the water rise higher or lower than half-way, then, by the rule of three, say, as the number to which the water rises is to one, so is thirty-three to the number of feet measuring the depth of the column required.

But since, when the instrument has descended to the depth of ninety-nine columns, or ninety-nine times thirty-three feet, the air will be compressed into the one-hundredth part of fifty inches, that is, into half an inch, the division both for some space below and also above that will be so very small that the difference in depth of several columns of water will not be sensible; so that an instrument of no greater length than this would scarcely give an accurate estimate of half a mile's depth, that is, 2640 feet, or 80 columns' depth of water. The lengthening of this instrument to four, five, or ten times this length would obviate this defect, and make the difference of the degrees of descent much more sensible. But since it is impracticable to make a metalline tube of so great a length, and if it were made it would be so unwieldy as to be easily broken, the difficulty may be obviated by having a large globe and tube like those employed in the common thermometer.

It was afterwards thought more desirable to employ an apparatus which, when it reached the bottom, should discharge a ball, so that the latter, having a less specific gravity than the water, should at once rise to the surface. Having, by a simple experiment,once ascertained the time of descent in a given quantity of water, it only became necesssary to keep an exact account of the time the machine remained under water, which might be done by a watch, or by a pendulum vibrating seconds. Dr. Hook found upon trial that a leaden ball which weighed two pounds, fixed to a wooden ball of the same weight, and both let down in fourteen fathoms' water, reached the bottom in seventeen seconds, and the detached wooden ball ascended to the surface in seventeen more. Consequently, if this machine descended and ascended greater depths with the same velocity, it would reach to the depth of a mile in seventeen minutes, and re-ascend in the like time. This, however, could be but a vague estimate until experience had furnished a rule.

This machine was tried in various depths in the Thames, and answered very well, always returning in the calculated time.

The general colour of the sea in the open ocean is a deep greenish-blue; the blue tint, which is predominant, seems to proceed from the same cause as the colour of the sky, the blue rays being reflected in the greatest quantity on account of their superior refrangibility. The other shades which have sometimes been observed in different seas seem to be owing to local causes, and often, perhaps, to optical illusions. In approaching soundings the water assumes a lighter shade. The luminous appearance of the sea by night is an imposing and magnificent phenomenon. It has been ascribed by some to animals of the zoöphyte and mollusca classes, which are said to possess phosphorescent qualities; some attribute it to the phosphorescence of decaying animal and vegetable substances; others to the spawn of fish. Some have explained it to be the effect of friction, but the appearances are extremely different at different times, and all these causes probably operate to produce them.

Observations made on the temperature of the sea show that the sun's rays rarely penetrate below the depth of forty-five, or, according to some, of 113

fathoms, below which the sea receives no light, and consequently little or no direct heat from the sun; and that the temperature increases with the depth to a certain degree, but never to freezing. The constant motion of the sea contributes in some measure to render its temperature equable. "We must distinguish," says Humboldt, "four different phenomena with respect to the ocean—the temperature of the water at the surface in different latitudes, the decrease of temperature in the lower strata, the effect of waves on the temperature of the surface, and the temperature of currents. The region of warmest water is between 5° 45′ N. and 6° 15′ S lat., and different observations give from 82 to 84 as the maximum. In the parallel of warmest waters the temperature of the surface of the sea is from 3° to 5° higher than that of the superincumbent air." The observations of Humboldt also show that both in the Atlantic and Pacific in changing the latitude and longitude the waters often retain nearly the same temperature over a great extent, and that between 27° N. and 27° S. lat. the temperature of the sea is entirely independent of the changes in the atmosphere. From the equator to 25° or 28 N. there is a remarkable constancy of temperature, but in higher latitudes there is more change. The great periodical oscillations of the sea, caused by the attraction of the sun and moon, are treated of in the article TIDES. In some places springs of fresh water are observed to issue from the sea entirely unaffected by the salt water. The most remarkable of these phenomena are in the Gulf of Spezia, in the Persian Gulf, and in the bay of Xagua, on the south coast of Cuba. It is probable that these are subterraneous streams, which find their way under the bed of the ocean until they encounter a fissure, into which they are impelled in the same manner as spouting springs on land.

The great divisions of the sea appear to be inhabited by their peculiar fish, mollusca, zoöphytes, &c., and to be frequented by peculiar species of birds. The level of the sea is, generally speaking, every where the same. This arises from the equal pressure in every direction which the particles of a fluid exercise upon each other. The ocean therefore considered as a whole has a spherical or a spheroidal surface, which may be considered as the true surface of our planet.

Different statements have been given of the quantity of saline matter in the waters of the ocean, some chemists asserting that the waters taken in different situations do not differ materially: others stating that the waters of different latitudes, and at different depths, contain different quantities of saline matter.

According to Glauber, the sea-water which he examined contained 3.01 per cent. of saline matter. Bouillon, Lagrange, and Vogel, in their experiments on the waters of the English Channel, of the Bay of Biscay, and of the Mediterranean, found that the saline ingredients amounted to 3.47 per cent. Bergman states that the water from the latitudes of the Canaries contained 3.59 per cent.; while, according to Dr Murray, the saline matter in the water of the Frith of Forth is only 3.03 per cent. From the experiments of Pages, it appears that sea-water, procured in south latitude 1° 16′, contained 3.5 per cent. of saline ingredients; in south latitude 20°, the quantity was 3.9 per cent; in south latitude 40°, it was 4 per cent; and in 46°, it was 4.5 per cent.; the quantity of saline matter gradually becoming greater on receding from the equator.

In the waters collected in the northen latitudes by the same gentleman, the proportion of saline ingredients did not differ from each other, being in the different trials 4 per cent.

From experiments made by Dr. Fyfe on sea-water, procured in different degrees of *north* latitude, and from different depths, there does not seem to be any material difference in the quality of saline matter. The specimens examined were collected by Captain Scoresby in his voyages to the Greenland Seas, and also by Captain Ross of his Majesty's ship Isabella, during the northern expedition.

The experiments to ascertain the quantity of saline ingredients in the different specimens of sea-water were performed on a large scale, that there might be as little chance of error as possible. For this purpose, ten ounces of each were slowly evaporated; the residue of the evaporation was then subjected to a heat sufficient to render it dry, and weighed in the vessel before being allowed to cool, as it very quickly attracted moisture. The results are given in the following table:—

	N. Latitude.	Longitude.	Remarks	Specific gravity at 45° F.	Saline matter per cent.
A	61° 52′	0° 7′ W.	Blue sea; water from surface; transparent and colourless.	10274	3.70
B	64° 26′	0° 38′ E.	Ditto, ditto.	10274	3 54
C	66° 45′	1° 0′ E.	Ditto. ditto. Smell of sulphuretted hydrogen, gave a black precipitate with the acetate of lead.	10272	3.79
D	69° 14′	3° 0′ E.	Blue sea; water from the surface, transparent and colourless.	10272	3.75
E	67° 50′	1° 30′ W.	Sea greenish-blue; water from surface; turbid; after filtration slightly opaque. N. B. This water was exposed to the air after being collected, by which part of it had evaporated.	10276	3.77
F	71° 10′	5° 30′ E.	Blue sea: water from the surface, transparent and colourless.	10272	3.75
G	74° 34′	10° 0′ E.	Ditto, ditto.	10276	3.77
H	74° 50′	59° 15′ W.	Water from the surface, transparent and colourless.	10263	3.33
I	74° 50′	59° 15′ W.	Water transparent and colourless, taken at the depth of eighty fathoms, by Sir H. Davy's bottle; its temperature at the moment that it was drawn was 30½°. H. M. S. Isabella, July 18, 1818.	10265	3.30
K	75°	65° 32′ W.	Water transparent and colourless, from eighty fathoms deep. August 12, 1818.	10256	3.62
L	76° 33′	10° 20′ E.	Blue sea: water from the surface, transparent and colourless.	10274	3.60

	N. Latitude.	Longitude.	Remarks.	Specific gravity at 45° F.	Saline matter per cent.
M	77° 30′	6° 10′ E.	Sea deep olive-green. Some ice; water when taken very thick. After standing, transparent and colourless,	10267	3.42
N	77° 34′	8° 0′ E.	Blue sea. Among ice-streams. Water from the surface, transparent and colourless,	10267	3.70
O	78° 25′	8° 20′ E.	Sea greenish-blue. Middle Hook of Charles Island. Spitzbergen E. 6 N. 7 leagues. Water from the surface, transparent and colourless,	10276	3.91
P	78° 30′	6° 30′ E.	Sea olive-green. Middle Hook of Charles Island E½. S. 9 leagues. Water from surface, transparent and colourless,	10276	3.88
Q	78° 35′	6° 0′ E.	Sea deep olive-green. Some ice; water from the surface. When taken very thick, after standing transparent and colourless,	10256	3.27

The results of the above experiments show that the water of the ocean, from north latitude 61° 52′ to north latitude 78° 35′ does not differ essentially in the quantity of saline matter which it contains, the smallest quantity being 3.27 per cent., the greatest 3.91 per cent. The average quantity of saline ingredients in the water within these latitudes is 3.50 per cent.

If the experiments of Pages be correct, the saline substance contained in the water of southern latitudes is greater than that in the water north of the equator. At south latitude 20° the saline ingredients amount to 3.9, and at south latitude 46° to 4.5 per cent.; while the greatest quantity in the water of the north seas, according to Dr. Fyfe's experiments, is only 3.91 per cent. in water procured at north latitude 78° 25′, upwards of 30 degrees further distant from the equator than the southernmost latitude at which Pages collected the water on which his experiments were performed.

We pass from the experimental investigations of Dr. Fyfe, to a very important paper published by Dr. Marcet. His attention appears to have been directed at a very early period to the analysis of water; and when the late celebrated Mr. Tenant received from Sir Joseph Banks some phials of the water of the Dead Sea and of the River Jordan, brought home by Mr. Gordon of Clunie, he entrusted them to Dr. Marcet, whom he knew to have been engaged in similar researches. These emiment chemists embraced every opportunity of collecting sea-water from different parts of the world; and, though the melancholy death of Mr. Tennant interrupted for a considerable time the researches of his friend, he was induced to resume his labours after the return of the Arctic Expedition, which furnished him with numerous specimens of water from the Polar Seas.

Having procured above seventy different kinds of sea-water from different parts of the world, a great number of which were raised by an ingenious apparatus invented by himself, Dr. Marcet began his investigation of their physical properties, and their chemical composition. The specific gravities were measured in the usual manner, by comparison with equal bulks of distilled water of the same temperature. As the results would occupy too much room, we have arranged them in the following table in groups, and given the extremes, as well as the mean, of the different results.

Places where the water was obtained.	Number of Specimens.	Intervals of Latitude.	Intervals of Longitude.	Extremes of Specific Gravity.	Mean of all the Results.
Arctic Ocean.	12.	66° 50′ to 80 29	11° 15′ E. to 76 46 W.	1.02555 to 1.02727	1.02664
Northern Hemisphere.	15.	3 28 63 49	89 0 E. 55 38 W.	1.02648 1.0309	1.02829
Equator.	4.	0 0	92 0 E. 25 30 W.	1.02692 1.02825	1.02777
Southern Hemisphere.	10.	8 30 35 33	73 0 E. 56 0 W.	1.02545 1.03209	1.02882
Yellow Sea.	1.	35 0 N.	——	1.02291	——
Mediterranean.	3.	36 0 N.	5 0 W.	1.0273 1.0305	1.0293
Sea of Marmora.	4.	40 5 N. 41 0 N.	26 12 E. 29 0 E.	1.01328 1.02819	1.01915
Black Sea.	2.	——	——	1.01414 1.01422	1.01418
White Sea.	2.	65 15 N.	39 19 E.	1.01894 1.01909	1.01901
Baltic.	3.	56 0 N. 57 39 N.	15 0 E. 12 40 E.	1.0049 1.02593	1.01523
Ice-sea waters	6.	75 40 80 28	13 40 E. 65 32 W.	1.00000 1.00235	1.00057
Lake of Ourmia.	1.	——	——	1.16507	——

From the preceding facts Dr. Marcet concludes,

1. That the Southern Ocean contains more salt than the Northern Ocean, in the ratio of 1.02919 to 1.02757.

2. That the mean specific gravity of sea-water near the equator is 1.02777, intermediate between that of the northern and southern hemispheres.

3. That there is no considerable difference in sea-water under different meridians.

4. That there is no satisfactory evidence that the sea at great depths is more salt than at the surface.*

5. That the sea in general contains more salt where it is deepest and most remote from land, and that its saltness is always diminished in the vicinity of large masses of ice.

6. That small inland seas, though communicating with the ocean, are much less salt than the open ocean.

7. The Mediterranean contains rather larger proportions of salt than the ocean.

The singularity of this last result has been explained upon the supposition that the Mediterranean is not supplied by the rivers which flow into it with a quantity of fresh water sufficient to replace what it loses by evaporation under a burning sun, aided by a powerful radiation from the African shores, and the parching winds blowing from the adjacent deserts. Philosophers have, therefore, attempted to explain why this sea does not gradually increase in saltness, and indeed be ultimately converted into saturated brine. This has been ascribed to an under current of water, salter than the ocean, which runs out at the Straits of Gibraltar, and unloads its waters of their excess of salt. This idea of a submarine current is countenanced by the fact, communicated to Dr. Marcet by Dr. Macmichael, on the authority of the British consul at Valentia, that some years ago a vessel was lost at Ceuta, on the African coast, and its wreck afterwards thrown up at Tariffa, on the European shore, fully two miles west of Ceuta.*

The results obtained by Dr. Marcet from twelve specimens of water from the Arctic Seas agree wonderfully with those previously obtained by Dr. Fyfe, the intervals of latitude and longitude being nearly the same, and also with those of Mr. Scoresby, published in his work on the Arctic Regions.

	Number of Specimens.	Intervals of Latitude.	Intervals of Longitude.	Specific Gravity.
Dr. Fyfe's result,	16.	61° 52′ N. 78 25 N.	10° 20′ E. 65 32 W.	1.02697
Dr. Marcet's result,	12.	66 50 N. 80 29 N.	11 15 E. 76 46 W.	1.02664
Mr. Scoresby's result,	14.	76 16 N. 80 0 N.	90 0 E. 0 10 W.	1.02653

Dr. Marcet next proceeds to give an account of the general results respecting the temperature of the Polar Seas, as obtained by the officers of the late expedition to those regions.

In Baffin's Bay, the Mediterranean Sea, and the tropical seas, *the temperature of the sea diminishes* with the depth, according to the observations of Phipps, Ross, Parry, Sabine, Saussure, Ellis, and Peron; but it is a remarkable fact that in the Arctic or Greenland Seas *the temperature of the sea increases* with the depth. This singular result was first obtained by Mr. Scoresby, in a series of well-conducted experiments, and has been confirmed by the later observations of Lieutenants Franklin, Beechy, and Mr. Fisher.

The following is an abstract of Mr. Scoresby's results:—

Lat.	Long.	Depth in Feet.	Temperature.	Temper. of Air.
76° 16′	9° 0′ E.	Surface	28.8°	12°
	——	300	31.8	
	——	738	33.8	
76 16	10 50	Surface	28.3	16
	——	738	30.0	
76 34	10 0	Surface	30.0	25
	——	600	34.7	
77 15	8 10	Surface	29.3	16
	——	600	30.0	
77 40	5 40	Surface	29.0	34
	——	2400	30.0	
79 4	5 38	Surface	29.0	38
	——	4380	37.0	
80 0	5 0	Surface	29.7	40
	——	720	36.3	
78 2	0 10 W.	Surface	32.0	36
	——	4566	38.0	

The following are some of the results obtained by Lieutenant Beechy on board the Trent:—

Lat.	Long.	Depth in Fath.	Temper. at Bottom.	Temper. of Surface.
79° 44′	9° 34′ E.	15	34.0°	33.0°
79 58	11 14	30	31.0	30.0
79 52	9 57	60	34.0	32.0
80 23	9 50	120	36.0	30.3
80 21	11 11	140	36.5	30.5
80 27	11 5	200	35.5	32.5
80 23	11 3	237	27.0	32.0
76 48	12 26	700	43.0	33.0

The following are some of Mr. Fisher's results, obtained on board the Dorothea:—

Latitude.	Longitude.	Depth in Fath.	Temp. at Bottom.	Temp. of Surface.
Between 79° 51′ and 80 14	11° 30′ E.	40	35.5°	31.8°
		60	36.0	32.0
		100	36.3	32.0
		124	36.7	33.5
		140	36.5	32.0
		188	42.5	33.0
		304	39.0	31.0

The greatest difference found by Lieutenant Parry was 6°, at a depth of 246 fathoms; and the greatest obtained by Captain Sabine was 7½°, at a depth of 680 fathoms.

The following table contains the results obtained by Dr. Marcet:—

* A similar conclusion was deduced by Mr. Scoresby, who obtained the following results. See his *Account of the Arctic Regions*.

	Depth in feet.	Spec. Grav.		Depth in feet.	Spec. Grav.		Depth in feet.	Spec. Grav.
Lat. 76° 16′	Surface.	1.0261	Lat. 76° 34′	Surface.	1.0265	Lat. 77° 40′	Surface.	1.0267
	738	1.0270		120	1.0264		300	1.0265
	1380	1.0269		240	1.0266		660	1.0262
				360	1.0268			
				600	1.0267			

Synthetic View of the Results obtained from the Analysis of different Seas; the Quantity of Water operated upon being supposed to be 500 Grains.

Description of the Specimens.	Specific Gravity.	Residue from Evaporation of 500 grs. water.	Muriate of Silver.	Sulphate of Barytes.	Oxalate of Lime.	Phosphate of Magnesia.	Total of Precipitates from 500 grs. water.	Observations.
		Grains.	Grains.	Grs.	Grs.	Grs.	Grains	
Arctic Ocean. Spec. 1.	1027.27	19.5	39.7	3.3	0.85	2.7	46.55	The quantity actually operated upon was 500 grains.
Arctic Ocean. Spec. 12.	1019.7	14.15	27.9	2.4	0.7	1.8	32.8	From surface. Quantity operated upon 500 grains.
Arctic Ocean. Spec. 67.	1002.35	1.75	3.2	0.1	0.05	0.03	3.37	Sea-ice water; coast of Spitzbergen. Operated on 500 grains.
Arctic Ocean. Spec. 14.	1027.05	19.3	38.9	3.25	0.95	2.9	46.	From a depth. Operated on 500 grains.
Equator. Spec. 35.	1027.85	19.6	40.3	3.7	0.9	3.1	48.	From surface. Operated on 500 grains.
S. Atlantic. Spec. 41.	1028.19	20.6	40.4	3.75	1.0	3.2	48.3	Operated on 250 grains.
White Sea. Spec. 58. & 59.	1022.55	16.1	31.8	3.0	0.6	2.2	37.6	Operated on 500 grains, but evaporated only 250 grs.
Black Sea. Spec. 56. & 57.	1014.22	10.8	19.6	1.95	0.55	1.5	23.6	Operated on 500 grains for the earths; on 250 for mur. of silver and evap. of water.
Baltic. Spec. 60.	1004.9	3.3	7.	0.7	0.2	0.6	8.5	Operated on 250 grains. The precipitates slightly tinged by veget. or anim. matter.
Sea of Marmora. Surface. Spec. 53.	1020.28	14.11	28.4	2.65	0.4	2.35	33.8	Entrance of Hellespont. Surface. Opd. on 500 grs. except for mur. of silver.
Sea of Marmora. Bottom. Spec. 52.	1028.19	21.	40.4	3.55	0.9	3.2	48.05	From bottom. Carbon of lime deposited during evap. but none from the water at surface. Operated on 500 grains.
Middle of North Atlantic. Spec. 27.	1028.86	21.3	42.	3.85	0.8	2.7	49.35	Operated on 250 grains for evap. of water and mur. of silver. 500 for other salts.
Yellow Sea Spec. 48.	1022.91	16.1	32.9	1.35	0.75	2.2	37.2	During concentration deposited carbon. of lime. The water was yellowish and had a strong hepatic smell. Operated on 500 grains.
Mediterranean. Spec. 51.	1027.3	97.7	38.5	3.6	0.8	3.0	45.9	From Marseilles, and rather weak, from vicinity of rivers. Opd. on 100 grains for evap. and mur. of silver; and 250 for other salts.
Dead Sea.	1211.	192.5	326.4	0.5	9.78	55.5	584.68	*Phil. Trans.* 1807.
Lake Ourmia, in Persia.	1165.07	111.5	237.5	66.0	0.	10.5	425.5	Spec. brought by Brown. Operated on 100 and 50 grains.

By cooling sea-water with freezing mixtures, and ascertaining its specific gravity at each degree of temperature, as it approached congelation, Dr. Marcet found that the law of maximum density at 40° did not prevail in the case of sea-water; but, on the contrary, sea-water gradually increased in weight down to the freezing point. This able chemist confirmed this result by means of an ingenious instrument, with which he measured the bulk of the water under various temperatures. The water was always found to contract in bulk down to 22° of Fahrenheit, when the water appeared to expand a little, and con-

tinued to do so till its temperature descended to between 19° and 18°, when the fluid suddenly expanded to a very considerable degree, shooting up with great rapidity, and forcing itself out of the open end of the tube. At the same moment the thermometer rises to 28°, and remains at that point. The liquid is now found frozen, and in a few minutes the maximum of expansion is obtained.

Dr. Marcet next proceeded to ascertain the saline contents of the different seas; and in this investigation he employed a method which he had previously used and explained in his analysis of the Dead Sea, published in the *Phil. Trans.* for 1807. "It is satisfactory to observe," says Dr. Marcet, "that Dr. Murray adopted, several years afterwards, a mode of proceeding precisely similar, and indeed that he proposed, in a subsequent paper (*Edin. Trans.* 1816, vol. viii.), a general formula for the analysis of mineral waters, in which this method is pointed out as likely to lead to the most accurate results. And this coincidence is the more remarkable as it would appear, from Dr. Murray not mentioning my labours, that they had not at that time come to his knowledge." All the results which Dr. Marcet obtained by this mode of investigation, prove that sea-water contains the same ingredients all over the world, and that these bear very nearly the same proportion to each other, differing only in the total amount of their saline contents. See *Edinburgh Philosophical Journal.*

Octagon, in *geometry*, is a figure of eight sides and angles, which, when the sides and angles are all equal, is called a *regular octagon*, and when they are not equal, an *irregular octagon.*

Octahedron or Octaedron; a body consisting of eight equal and equilateral triangles.

Octant, an astronomical instrument, is the eighth part of a circle divided into degrees, for the purpose of calculating the amplitude of the stars, but it is now little used.

Octave, in the diatonic system of musical sounds; the eighth sound from an assumed fundamental tone. It belongs to the perfect concordant intervals, so that when it is sounded with the fundamental, the ear scarcely perceives more than one sound, and is hardly able to distinguish the one from the other. For this reason, the octave must, in our musical scale, be perfect; whereas the other intervals may be tuned somewhat higher or lower than their true pitch. The upper octave (that is, the one which is eight notes above the fundamental) is obtained when the string which sounds it is only half as long, and the lower octave when this string is twice as long, as that of the fundamental. The string which sounds the upper octave in each makes two vibrations while the string of the fundamental makes one. Therefore on the eighth diatonic string the tone of the first, or lowest, recurs. The ninth string repeats the second tone, called the *second*, the tenth string the third tone, or the *third*, &c.

According to the arrangement of our new or diatonic system of tones, the octave is the limit within which the seven essential tones are kept distinct from each other: and all tones without the limit of the octave are only repetitions, in an augmented or diminished degree, of the tones already contained in the compass of the octave. For this reason we call the octave the whole extent of the tones of the diatonic system. The number of upper and lower octaves, or the manner in which several octaves of different heights are to be chiefly distinguished, is not absolutely determined, on account of the continually increasing compass of instruments, particularly stringed instruments, and especially the piano-forte, which, within a short period, has been considerably increased.

The octave, considered as an interval, has of all intervals the least harmonic effect. On this account composers, when there is only one principal voice, forbid rising to the octave except at the beginning or close. But a succession of octaves following each other, when a melody is to be raised in that manner, has a very good effect. False or disallowed octaves are, in musical compositions for many voices, progressions of two voices in exact movement by octaves, which offend the ear. The reason why such progressions by octaves are disallowed in a musical piece for many voices is evident, because, when two voices proceed by octaves, no difference can be perceived between these two; and, for example, a piece for four voices becomes one for two. There are also those which are called *covered octaves*, that is, such as become for the first time distinguishable when the interval of the two voices, proceeding in an exact movement by octaves, is filled up with unimportant notes. Of the compositions for two voices, or in the two upper parts of composition for three or four voices, those alone are free from fault in which the upper part rises or falls a second, but the fundamental a fourth or fifth. The use of the others is allowed only under the middle part, or between an upper and a middle part.

Octave, also, in an organ, signifies the open flute stop, which is one or two octaves higher than the principal.

October; originally the eighth month in the Roman calendar, whence its name, which it still retained after the beginning of the year had been changed from March to January.

Odontalgic, in *medicine;* a term applied to all remedies for the tooth-ache. When the affection is rheumatic, blistering behind the ear, or applying flannel dipped in spirits and covered with ginger or pepper, will generally cure; but, when it proceeds entirely from the injury of a carious tooth, the pain is much more obstinate. In this case it has been recommended to touch the pained carious part of the tooth with a hot iron, or with oil of vitriol, in order to destroy the aching nerve, to hold spirits in the mouth, to put a drop of oil of cloves into the hollow of the tooth, or a pill made of camphor, opium, oleum caryophylli. But one of the most useful applications of this kind is strong nitrous acid, diluted with three or four times its weight of alcohol, and introduced into the hollow of the tooth either by means of a hair pencil or a little cotton. When the constitution has had some share in the disease, the Peruvian bark has been recommended, and perhaps with much justice, on account of its tonic and antiseptic powers. When the pain is not fixed to one tooth, leeches applied to the gum are of great service. But very often all the foregoing remedies will fail; and the only infallible cure is to draw the tooth.

Odour, that quality of certain bodies which excites the sensation of smell. In the *Annales de Chimie*, we have a detailed account of a series of experiments made by M. Prevost, with a view to render the emanations of odorant bodies perceptible to sight. We have space only for a few passages illustrative of the author's views.

1. A concrete odorant substance, laid upon a wet glass or broad saucer, covered with a thin stratum of water, immediately causes the water to recede, so as to form a space of several inches around it.

2. Fragments of concrete odorant matter, or small morsels of paper or cork impregnated with an odorant liquor, and wiped, being placed on the surface of water, are immediately moved by a very swift rotation. Romieu had made this observation on camphor, and erroneously attributed the effect to electricity. The motion was perceptible even in pieces of camphor of seven or eight gros.

3. An odorant liquor being poured on the water stops the motion till it is dissipated by evaporation. Fixed oils arrest the motion for a much longer time, and until the pellicle it forms on the water is taken off.

4. When the surface of the water is cleaned by a leaf of metal, of paper, or of glass, plunged in and withdrawn successively until the pellicle is removed, the gyratory motion is renewed. If a piece of red wax or of paper be dipped in water, and the drops shaken off into a glass of water containing odorant bodies in motion, the movement will be stopped. The same effect is not produced by metal.

5. A small piece of camphor, plunged to the depth of three or four lines in water, without floating, excites a movement of trepidation in the surrounding water, which repels small bodies in its vicinity, and carries them again to the camphor by starts. The author concludes that an elastic fluid escapes from the odorant body in the manner of the fire of a fusee, or the discharge of fire-arms.

6. When there is a certain proportion between the height of the water and that of the small fragment of camphor, the water is briskly driven off, returns again to the camphor, and again retires, as if by an explosion, the recoil of which often causes the camphor to make part of a revolution on its axis.

7. Camphor evaporates thirty or forty times more speedily when placed upon water, than when entirely surrounded with air.

8. Camphor, during the act of dissipation in the air, preserves its form and its opaque whiteness; upon water it is rounded, and becomes transparent as if it had undergone a kind of fusion. It may be inferred that this arises from the acquired motion which causes it to present a greater surface to the air.

9. When small pieces of camphor are plunged in water, the camphor becomes rounded and transparent, does not acquire any motion, and its dissipation is less perceptible than in the air. The concurrence of air and water is therefore necessary to disengage the fluid, which is the cause of the motion and total dissipation of odorant bodies.

10. The motion of odorant bodies upon water decays and ceases spontaneously at the end of a certain time; because, the water having then contracted a similar character with the body, the volatilization takes place in all the points of its surface; and the small mass being thus surrounded by the odorant fluid, which is no longer air, dissolves, as in the ordinary odorant fluids, without forming the gaseous jet which is the cause of the motion. The author compares the volatilization of the aromatic substance to a combustion excited by water.

Professor Ventury of Modena, who heard Prevost's memoir read in the National Institute, had himself made some experiments with camphor kept separately in the air, in the water, and at the surface of the water; whence he deduces that the most active virtue for dissolving camphor resides at that part where both the air and the water touch the camphor at the same time. Hence he explains why, in like circumstances, camphor evaporates more quickly in a moist than in a dry air; and why the natives of Holland use water in their process for subliming this substance.

It might be thought that the camphor was decomposed at the surface of the water; that the water might seize the acidifying part, which renders the camphor concrete; and that the volatile part is dissipated in the atmosphere. The author rejects this notion. He thinks that water with camphor floating on its surface becomes charged with no more than a very small portion: 1. Because in these circumstances the water acquires the same taste and smell of camphor as it obtains when a small quantity of this substance is kept plunged in the same fluid. This water, by exposure to the air, loses the qualities with which it had been charged, and becomes insipid and without smell. 2. Because, when the water is saturated with all it can take up, the dissipation of the camphor continues at its surface as before. 3. Because the aërial emanations of camphor made at the surface of water do themselves crystallize into camphor.

Œsophagus.—The gullet is a contracted continuation of the pharynx, the last part of the fauces. Its anterior part is connected with the root of the tongue, the os hyoides, and the larynx; it closely adheres behind to the vertebræ of the neck, and is moved by various muscles, which elevate or dilate the pharynx, and by others which shut it. One pair of these muscles, arising by three origins from the os hyoides, the cartilago cricoides, and the cartilago thyroides, totally surrounds the pharynx. The *œsophagus* first runs straight between the aspera arteria and the vertebræ of the neck and back, but turns to the right about the fifth vertebra, and to the left about the ninth; then proceeding through the middle of the thorax and the muscular part of the diaphragm, behind the little lobe of the liver, it terminates in the superior orifice of the stomach. The œsophagus consists of four coats: the outermost coat is a thin, vascular, cellular membrane, originating from the pleura, uniting the gullet to the adjacent parts. The next coat is muscular, furnished with orbicular fibres, and above these with longitudinal ones. The third is nervous, common to the mouth and fauces, and extending a little way within the stomach; it is glandular, and the glands secrete a mucous. The innermost coat is covered with mucous, is villous, and the orifices of the glands are numerous. The cuticle lines the œsophagus, but is too thin to be demonstrated. Besides the glands mentioned, the dorsal gland about the fifth vertebra of the back, adhering to the gullet, and the thyroid gland, situated between the thyrocricoid cartilage and the œsophagus, are enumerated as belonging to this organ. Its upper part receives arteries from the internal carotids, its middle from the aorta and intercostal, and its inferior from the gastric arteries. Veins from the jugulars, from the vena sine pari, and from the caronary veins of the stomach, return the blood in the respective portions. The nerves proceed from the par vagum.

There are few situations in which foreign bodies lodge more frequently than in the œsophagus. The

function of this tube explains the reason of this occurrence, and its nearness to the wind-pipe accounts for the danger of suffocation, whenever a foreign body above a certain size is lodged in it. Foreign bodies, liable to stick in the œsophagus, are not only food, such as pieces of crust, or meat imperfectly chewed, but also various substances which are accidentally swallowed alone, or with the food, such as small bones, stones, pins, pieces of money, &c. These latter articles, by lodging in the pharynx or œsophagus, may occasion very bad symptoms; and, if forced down into the stomach, may produce still worse effects. Hence we should immediately try to extract them. For this purpose, the fingers are to be used, and, if they cannot reach them, forceps must be employed. Some have recommended hooks, for the accomplishment of the object in view; others, various instruments, adapted to particular circumstances. The excitement of vomiting has been tried, and occasionally with success; but it is not free from danger, and the most distressing symptoms have been brought on by it.

When such extraneous substances cannot be extracted, they must be pushed down into the stomach, with some such instrument as a large bougie, or a whalebone probang, fifteen or sixteen inches long, and on the end of which a piece of fine sponge is firmly fastened. But when such bodies are, from their sharp-pointed, angular shape, or hurtful nature, likely to occasion perilous consequences, by being pushed down into the stomach, the plan must not be attempted. Sharp substances not unfrequently make their way to the surface of the body, and give rise to an abcess, out of which they are discharged.

Œnanthe (water hemlock); a plant employed in medicine. An infusion of the leaves are said to be of the greatest service in cutaneous diseases. It must, however, be employed with great care, as it is a virulent poison. It grows in great plenty all over Pembrokeshire, and is called by the inhabitants *five-fingered root:* it is much used by them in cataplasms, for the worst kind of whitlow. They eat some parts of it, but carefully avoid the roots and stalk. These indeed are of a most pernicious nature, and never fail to prove instantly fatal, unless a proper remedy is applied. The following instance of the effects of this plant on man may be relied on:—

"Three French prisoners, being in the fields near the town of Pembroke, dug up a large quantity of a plant with its roots (which they took to be wild celery), to eat with their bread and butter for dinner. After washing it, while yet in the fields, they all three ate, or rather only tasted, of the roots. As they were entering the town one of them was seized with convulsions. The other two ran and sent a surgeon, who endeavoured first to bleed, and then vomit him; but in vain, and he died presently. Ignorant of the cause of their comrade's death, and of their own danger, they gave some of these roots to eight other prisoners, who all ate of them with their dinner. A few minutes after, the two who gathered the plants were seized in the same manner as the first, of which one died: the other was bled, and an emetic with great difficulty forced down, on account of his jaws being set. This operating, he recovered; but was for some time much affected with a dizziness in his head, though not sick, or in the least disordered in his stomach. The other eight being bled and vomited immediately were soon well."

Offing, or Offin; that part of the sea a good distance from shore, where there is deep water, and no need of a pilot to conduct the ship.

Oil.—There exist two species of oil in vegetables, agreeing in the common properties of unctuosity and inflammability, but essentially different in many of their chemical qualities and relations. The one, from being capable of being volatilized without decomposition, is named volatile oil; the other is denominated fixed oil. The character of the latter must be first examined.

Fixed oils are generally contained in the seeds and fruits of those vegetables of which they are the products, and are formed principally at the period of maturity. They are extracted by pressure, whence they are named expressed oils, or in some cases by decoction with water. They are frequently impregnated with the mucilaginous or extractive matter of the vegetable, whence they acquire colour, odour, and taste; and if heat has been employed to favour their extraction by expression they acquire acrimonious qualities, and suffer even a change in some of their chemical properties. The purest oils are those expressed from the fruit of the olive or the seeds of the almond; others less pure are extracted from linseed, hempseed, and the seeds of other plants.

Fixed oils are usually fluid, but of a thick consistence, and they congeal at a moderate temperature: some are even naturally concrete; when fluid they are transparent, colourless, or of a yellow or green tinge, inodorous, and insipid; they are lighter than water; they are incapable of combining with water, and are very sparingly soluble in alcohol in the cold, with the exception of castor oil, which is abundantly dissolved by rectified alcohol, and of linseed oil, which is dissolved, though more sparingly; boiling alcohol dissolves it, and also the others in sensible quantity.

Expressed oils cannot be volatilized by heat unchanged. At temperatures below 600° of Fahrenheit they remain fixed; nearly at that temperature they are converted into vapour, but the oil thus condensed is altered in its properties; it has lost its mildness and has become more limpid and volatile, a portion of carbon being likewise deposited. Transmitted through an ignited tube, oil is converted into carbonic acid and carburetted hydrogen, with a small portion of acid liquor and a residuum of charcoal.

Exposed to a warm atmosphere, expressed oils gradually acquire a sharp taste and smell and become thick. This change, named rancidity, is owing to absorption of oxygen; hence it takes place sooner when the oil is exposed to oxygen gas, and a large quantity of the gas is frequently absorbed. Drying oils, as those expressed with the aid of heat are named, do not become rancid, but, by absorbing oxygen, are partially converted into a resinous kind of matter. By these drying oils the absorption of oxygen is under favourable circumstances so rapid as to give rise to spontaneous combustion.

At the temperature of ignition, at which it is converted into vapour, oil burns in atmospheric air, a large quantity of light and heat being extricated by its combustion. When the access of the air to the vapour of the oil is not complete it burns with a black smoke, and a quantity of carbonaceous matter which has escaped the combustion is deposited. Hence the utility of a slender wick, which draws up the oil by capillary attraction, and, when kindled, produces sufficient heat to convert it into vapour. In a hollow

cylindrical wick, as in the argand lamp, through which an internal circulation of air is established, the supply of air is more abundant and the whole of the oil is consumed; the illumination therefore is greater, though there is some diminution of it in consequence of the light from the internal surface having to pass through the flame.

Expressed oil is oxidated by a number of the acids. Sulphuric acid soon renders it black, the oxygen of the acid attracting part of the hydrogen of the oil and causing the deposition of charcoal; and if heat is applied a large portion of sulphurous acid is disengaged, and even sulphur is evolved. Nitric acid renders the oil thick and white; if heat is applied the action is more rapid and a yellow colour is communicated, the oil being rendered concrete. The drying oils are even inflamed. Muriatic acid exerts little sensible action; oxymuriatic acid thickens the oil and renders it white.

Expressed oil combines with the alkalies, and when the combination is perfect it forms soap. If one part of oil be mixed with half its weight of a strong solution of pure potash or soda, a thick white mass is formed, which can be diffused in water, forming a milky-like mixture. If the oil and the alkaline solution be boiled gently together, a more intimate combination is effected, and, on cooling, a solid compound separates from the liquor. The soap thus prepared differs according to the purity of the ingredients. Common soap is made of animal oil, or fat, or the coarser vegetable oils, with resin; the finer soaps are prepared from olive or almond oil. Potash forms a soap which always remains soft; soda forms one that is more solid and firm. Hence either a solution of carbonate of soda, from which the carbonic acid has been abstracted by lime, is employed in the preparation; or, if a solution of potash rendered caustic by the same operation be used, which is the common method in the preparation of the coarser soaps, there is added towards the end of the boiling a quantity of sea-salt, the soda of which, being in part evolved, has the same effect. The cleansing property of soap depends on its alkali; and, although the detergent power of this is weakened by the combination with the oil, advantage is gained from its softness and smoothness, and from the alkali in the state of combination acting less as a solvent on the cloth.

Soap is soluble in water, the solution being opaque, from the intermixture of particles of uncombined oil. It is also soluble in alcohol, forming a transparent solution. It is decomposed by all the acids and by the greater number of the earthy and metallic salts, the acid combining with the alkali and separating the oil. Hence spring water often decomposes it from the sulphate of lime it contains. The oil separated by these decompositions is soluble in alcohol, a proof that, by its combination with the alkali, it has undergone some chemical change. Soap decomposed by heat affords water, empyreumatic oil, and ammonia.

Ammonia forms with expressed oil a less intimate combination than the fixed oils do, as heat cannot be employed to favour the combination. The addition of a small quantity of it is employed in pharmacy to suspend oil in water. By adding an ammoniacal salt to a solution of soap an ammoniacal soap is obtained by double affinity. It is less soluble in water than common soap, and suffers decomposition from exposure to the air.

The combinations of expressed oil, with the earths and metallic oxides, may be obtained by adding their salts to a solution of soap, when a double decomposition takes place. These compounds have a saponaceous quality, but are in general less soluble in water than the alkaline soaps.

Expressed oil, when boiled on sulphur, combines with it, and forms a compound of a brown colour, an extremely fœtid smell, and an acrid taste. It likewise dissolves phosphorus with the aid of heat, forming a liquid which becomes luminous when exposed to the air.

Expressed oil, promotes the oxidation of some of the metals, as copper or mercury, by the action of the air. It combines with a number of the metallic oxides. Boiled with oxide of lead, it forms a compound of a firm consistence, which is named in pharmacy common plaster.

A mutual action is exerted between expressed oils and several of the other vegetable principles, as gum or resin. Triturated with mucilage, it forms a milky mixture,—a mode of suspending oil in water which is sometimes employed in pharmacy. It melts easily with resin.

Expressed oils, besides their use in pharmacy and medicine, form the basis of paints, being triturated with oxide of lead and the colouring matter. Combined with resins and turpentine, they form varnishes; and printing-ink is a composition of them with lamp black. For some of these uses the drying oils are employed.

Volatile or essential oil is contained in the flowers, fruits, leaves, wood, or bark of many vegetables, generally in inconsiderable quantity, the proportion varying, however, according to the age and vigour of the plant. The oil sometimes exists in distinct vesicles, and may therefore be obtained by expression. But the usual method to procure an essential oil is to subject the vegetable matter containing it to distillation with water.

Essential oils are odorous, sapid, and generally pungent, the taste and smell of the oils obtained from different vegetables being very different; the odour is always that of the plant from which they are procured. They are generally lighter than water, but some have a greater specific gravity. They are usually fluid, and remain so even at a low temperature; but some congeal even at a very moderate degree of cold, and others are naturally concrete. They are volatilized by a very moderate heat. By a strong heat suddenly applied, they are partially decomposed.

Essential oils are soluble in water in minute proportions. The water acquires the taste and flavour of the oil. This impregnation is commonly obtained by distillation, the distilled waters of pharmacy being thus formed. They are much more soluble in alcohol; some of them unite with the alcohol in every proportion, others in limited quantities; and there are even some which are sparingly dissolved. By distilling ardent spirit from vegetables containing much essential oil, distilled spirits are formed.

Exposed to atmospheric air, these oils lose their smell, are thickened, and become concrete, frequently depositing at the same time crystals of an acid nature. These changes are owing to the absorption of oxygen. The acid is similar to the benzoic, and the thickened oil approaches in its properties to resin.

When heated in contact with atmospheric air, they are more easily inflamed than the expressed oils, and

burn with a brighter flame, probably from their greater volatility; the products of the combustion are water and carbonic acid, and the water is in larger quantity than from the combustion of the fixed oils. Hence they differ from the fixed oils in containing a larger proportion of hydrogen, to which probably their greater volatility and inflammability are owing.

The essential oils are oxidated by the acids. Sulphuric acid renders them black, producing at the same time a considerable elevation of temperature, and frequently a violent effervescence, from the disengagement of sulphurous and carbonic acid gases. Nitrous acid communicates oxygen with such rapidity as frequently to inflame the oil. By a more slow action it forms prussic, malic, and oxalic acids, and converts the remaining oil into a kind of resinous substance. In some cases the acids combine with essential oils, and the acid properties are neutralized without decomposition.

With the alkalies these oils combine with difficulty, and the combination can be effected only by long trituration: the compound is slightly saponaceous. Liquid ammonia distilled with the oil combines with it but sparingly.

Sulphur dissolves with the aid of heat in any of the essential oils; the solution has an offensive smell. Phosphorus is also soluble in them; and some of these solutions (that, for example, in oil of cloves), are highly luminous.

These oils unite with mucilage or sugar; and by the medium of ether they may be suspended in water. They dissolve resin, camphor, and other vegetable principles.

In general they are used as perfumes, or in the practice of medicine. Some of them enter into the composition of varnishes.

Several chemists have been of opinion that herbs and flowers, moderately dried, yield a greater quantity of volatile oil than if they were distilled when fresh. It is, however, highly improbable that the quantity of volatile oil can be increased by drying; on the contrary, part of it must be dissipated and lost. But drying may sometimes be useful in other ways, either by diminishing the bulk of the subject to be distilled, or by causing it to part with its oil more easily; and aromatic waters distilled from the dry herb are more fragrant than from the fresh. But the directions sometimes given to dry the herb used in the distillation of volatile oils would be extremely inconvenient, as large quantities of the oils of lavender, peppermint, spearmint, and pennyroyal, are annually distilled in this country from the fresh herb; and the oils of aniseed, camomile, caraway, juniper, origanum, rosemary, and pimento, are usually imported.

The choice of proper instruments is of great consequence for the performance of this process to advantage. There are some oils which pass freely over the swan neck of the head of the common still: others, less volatile, cannot easily be made to rise so high. For obtaining these last, a large low head, having a rim or hollow canal round it, seems best: in this canal, the oil is detained in its first ascent, and is thence conveyed at once into the receiver, the advantages of which are sufficiently obvious.

We cannot separate the volatile oil from aromatic substances by distilling them alone, because the proportion of these oils is so small that they could not be collected; and, besides, it would be impossible to regulate the heat so as to be sufficient and yet not to burn the subject and destroy the product. Hence it is necessary to distil them with a proportion of water, which answers extremely well, as the oils are all more volatile in water, and soluble in it only to a certain extent.

With regard to the proportion of water to be employed, if whole plants moderately dried are used, or the shavings of woods, as much of either may be put into the vessel as, lightly pressed, will occupy half its cavity; and as much water may be added as will fill two-thirds of it. When fresh and juicy herbs are to be distilled, thrice their weight of water will be fully sufficient; but dry ones require a much larger quantity. In general there should be so much water, that, after all intended to be distilled has come over, there may be liquor enough left to prevent the matter from burning to the still. The water and ingredients altogether should never take up more than three-fourths of the still; there should be liquor enough to prevent any danger of empyreuma, but not so much as to be in danger of boiling over into the receiver.

The subject of distillation should be macerated in the water until it be perfectly penetrated by it. To promote this effect, woods should be thinly shaved across the grain or sawn, roots cut transversely into thin slices, barks reduced into coarse powder, and seeds slightly bruised. Very compact and tenacious substances require the maceration to be continued a week or two or longer; for those of a softer and looser texture two or three days are sufficient; while some tender herbs and flowers not only stand in no need of maceration, but are even injured by it. The fermentation which was formerly prescribed in some instances is always hurtful.

The fire ought to be quickly raised and kept up during the whole process; but to such a degree only that the oil may freely distil; otherwise the oil will be exposed to an unnecessary heat, a circumstance which ought as much as possible to be avoided. Fire communicates to all these oils a disagreeable impregnation, as is evident from their being much less grateful when newly distilled than after they have stood for some time in a cool place; and the longer the heat is continued the greater alteration it produces in them.

The greater number of oils require for their distillation the heat of water strongly boiling; but there are many also which rise with a heat considerably less; such as those of lemon and citron peel, of the flowers of lavender and rosemary, and of almost all the more odoriferous kinds of flowers. We have already observed that these flowers have their fragrance much injured or even destroyed by beating and bruising them; it is impaired also by immersion in water in the ordinary process, and the more so in proportion to the continuance the of immersion and the heat; hence oils distilled in the common manner prove much less agreeable in smell than the subjects themselves. For the distillation of substances of this class another method has been contrived: instead of being immersed in water, they are exposed only to its vapour. A proper quantity of water being put into the bottom of the still, the odoriferous herbs or flowers are laid lightly in a basket, of such a size that it may enter into the still and rest against its sides just above the water. The head being then fitted on, and the water made to boil, the steam, percolating through the subject, im-

bibes the oil without impairing its fragrance, and carries it over into the receiver. Oils thus obtained possess the odour of the subject in an exquisite degree, and have nothing of the disagreeable scent perceivable in those distilled by boiling them in water in the common manner.

Plants differ so much according to the soil and season of which they are the produce, and likewise according to their own ages, that it is impossible to fix the quantity of water to be drawn from a certain weight of them to any invariable standard. The distillation may always be continued as long as the liquor runs well flavoured off the plant, but no longer.

The mixture of water and oil which comes over may either be separated immediately by means of a separatory, or after it has been put into large narrow-necked bottles and placed in a cool place, that the portion of oil which is not dissolved in the water may rise to the top or sink to the bottom according to its specific gravity. It is then to be separated either by a separatory or by the use of a small glass syringe; or by means of a filter of paper; or, lastly, by means of a woollen thread, one end of which is immersed in the oil, and the other lower end in a phial: the oil will thus pass over into the phial by capillary attraction, and the thread is to be squeezed dry.

The water employed in the distillation of volatile oils always imbibes some portion of the oil, as is evident from the smell, taste, and colour which it acquires. It cannot, however, retain above a certain quantity; and hence such as has been already used, and therefore almost saturated, may be advantageously employed instead of common water in a second, or any future distillation of the same subject.

After the distillation of one oil particular care should be had to clean the worm perfectly before it be employed in the distillation of a different substance. Some oils, those of wormwood and aniseed, for instance, adhere to it so tenaciously as not to be melted out by heat, or washed off by water; the best way of removing these is to run a little spirit of wine through it.

Volatile oils, after they are distilled, should be suffered to stand for some days in vessels loosely covered with paper, till they have lost their disagreeable odour and become limpid: they should then be placed in small bottles, which are to be kept quite full and closely stopped, in a cool place. With these precautions they will retain their virtues in perfection for many years.

Most of the oils mentioned above are prepared by our chemists in this country, and are easily procurable in a tolerable degree of perfection; but the oils from the more expensive spices, though still introduced among the preparations in the foreign pharmacopœias, are, when employed among us, usually imported from abroad.

These are frequently so much adulterated that it is not easy to meet with such as are at all fit for use: nor are these adulterations easily discoverable. The grosser abuses indeed may be readily detected. Thus, if the oil be mixed with alcohol, it will turn milky on the addition of water; if with expressed oils, alcohol will dissolve the volatile, and leave the other behind; if with oil of turpentine, on dipping a piece of paper in the mixture, and drying it with a gentle heat, the turpentine will be betrayed by its smell. But the more subtile artists have contrived other methods of sophistication, which elude all trials of this kind.

Some have looked upon the specific gravity of oils as a certain criterion of their genuineness. This, however, is not to be absolutely depended on; for the genuine oils, obtained from the same subjects, often differ in gravity as much as those drawn from different ones. Cinnamon and cloves, whose oils usually sink in water, yield, if slowly and carefully distilled, oils of great fragrancy, which are specifically lighter than the aqueous fluid employed in their distillation; whilst on the other hand the last runnings of some of the lighter oils prove sometimes so ponderous as to sink in water.

The external use of oil as a medicine is of very high antiquity. It was a part of the complicated system of bathing, as employed by the ancients, either as a remedy or for the preservation of health. Bathing was of peculiar importance, since they were unacquainted with linen; and their woollen garments were not very regularly or very delicately cleaned. The peculiar advantages of oily applications, independent of the friction employed, except in giving softness and flexibility to the limbs, are not easily ascertained. After exercise they were undoubtedly refreshing, and prevented stiffness; but as preservatives they seem to have been chiefly useful in preventing the too copious perspiration. When we compare all the directions for anointing, we can see no other point in which they meet; and this, in a climate so warm, after violent exercise, and the relaxation of the warm bath, must have been an object of importance. The use of oil as an external remedy was introduced by Prodicus, more probably Herodicus, the inventor of gymnastics; and in fevers it seems to be directed to the purposes mentioned. We have not the works of this ancient author, but find copious directions for its use in Pliny. It still seemed an appendage to the bath; for, in slow fever, the oil was used in cold water; in the cold fits, united with warm substances. In general it was supposed to strengthen and fortify the body against the access of cold.

Independent of its subsidiary aid to the balneum, it was used by the ancients, in many diseases, applied externally, and often rubbed along the spine; in palsies, in lethargy, in tetanus, in dropsy, and in ephidrosis. In hydrophobia the patients were thrown into the cold bath, and then into oil; in melancholia, into a bath of water and oil. It was supposed to allay irritation, and we still retain its use in burns, in bites of insects, in prurigo, &c.; but the ancients employed it to allay pain after severe operations, to soften the exuberant callus of bones, to remove the pain attending luxations or wounds. St. Luke, whom we may quote as an intelligent physician, describes the good Samaritan as pouring oil and wine into the wounds of him who fell among thieves (ch. x. 34).

When luxury increased this salutary custom was, as usual, abused, and the oil was combined with the most costly perfumes. The simplicity of ancient manners consigned without a blush the fatigued body of the traveller to the hands of a female; but this custom was afterwards extended, and the bath became the scene of wantonness and lust. In the progress of empire, of science, and the arts, eastward, the use of oil might have been carried into that

luxurious region, unless the same necessity which suggested it in Greece introduced it also into Hindostan; though the cotton dress would in a great degree render the use of the bath less necessary.

In the east the use of oil, however, seems of considerable antiquity; and, besides the more obvious effects of giving sleekness to the skin and flexibility to the limbs, it is supposed to assist the strength, increase the secretion of fat and other fluids, as well as to prolong life. The Hindoos use oil to cure fevers, epilepsy, mania, dropsy, worms, and cutaneous diseases; to relieve pains from bruises, and the colic; to prevent bad effects from the bites of mad animals and of serpents.

Modern practice continues the application of oil to allay irritation, particularly the pains felt in old fractures or wounds on the change of weather, as advised by Rosenstein; and in irritations of the genital organs, as recommended by Hufeland.

Oil was used externally by the ancients in low fevers, and the practice continued in Egypt to the time of Prosper Alpinus. On this foundation it may have been recommended in the plague, in which it has been said to be of essential use. Its advantages, however, arise not from the oil, but from the friction; for, unless continued so as to excite perspiration, it is of little utility. In dropsies also the oil seems only to assist the friction, by preventing the excoriation which might otherwise soon occur. In tetanus, if ever useful, it is also perhaps in consequence of the friction and the perspiration excited by means of the friction.

In the bites of insects it seems to relieve pain, but in those of serpents Fontana found it inefficacious; nor are the experiments of Mr. Baldwin on its effects in the bites of scorpions, or rats, unexceptionable. In hydrophobia it has been recommended on the authority of an ancient Greek manuscript; and, though we have received accounts of cases in which it seemed to relieve the spasms, it has not been found to cure the disease.

That oil may be useful in securing a person from contagion appears from evidence apparently more decisive. From very different sources we find that oil porters, oil sellers, tallow-chandlers, and tanners, are usually exempt from the plague and the worst epidemics.

Volatile oils, medicinally considered, agree in the general qualities of pungency and heat; in particular virtues they differ as much as the subjects from which they are obtained, the oil being the direct principle in which the virtues, or at least a considerable part of the virtues, of the several subjects reside. Thus the carminative virtue of the warm seeds, the dieretic of juniper berries, the emmenagogue of savine, the nervine of rosemary, the stomachic of mint, the cordial of aromatics, &c. are supposed to be concentrated in their oils.

There is another remarkable difference in volatile oils, the foundation of which is less obvious—that of the degree of their pungency and heat. These are by no means in proportion, as might be expected, to those of the subject they were drawn from. The oil of cinnamon, for instance, is excessively pungent and fiery; in its undiluted state it is almost caustic; whereas cloves, a spice which, in substance, is far more pungent than the other, yields an oil which is much less so. This difference seems to depend partly upon the quantity of oil afforded, cinnamon yielding much less than cloves, and consequently having its active matter concentrated into a smaller volume, partly upon a difference in the nature of the active parts themselves; for though volatile oils contain always the specific odour and flavour of their subjects, whether grateful or ungrateful, they do not always contain the whole pungency: this resides frequently in a more fixed matter, and does not rise with the oil. After the distillation of cloves, pepper, and some other spices, a part of their pungency is found to remain behind; a simple tincture of them in alcohol is even more pungent than their pure essential oils.

The more grateful oils are frequently made use of for reconciling to the stomach medicines of themselves disgustful. It has been customary to employ them as correctors for the resinous purgatives; a use to which they do not seem to be well adapted. All the service they can here be of is to make the resin sit more easily at first on the stomach; far from abating the irritating quality upon which the violence of its operations depends, these pungent oils superadd a fresh stimulus.

Volatile oils are never given alone, on account of their extreme heat and pungency; which in some is so great that a single drop let fall upon the tongue produces a gangrenous eschar. They are readily imbibed by a piece of dry sugar, and in this form may be conveniently exhibited. Ground with eight or ten times their weight of sugar, they become soluble in aqueous liquors, and thus may be diluted to any assigned degree. Mucilages also render them miscible with water into a uniform milky liquor. They dissolve likewise in alcohol; the more fragrant in an equal weight, and almost all of them in less than four times their own weight. These solutions may be either taken on sugar, or mixed with syrups, or the like. On mixing them with water, the liquor grows milky, and the oil separates.

The more pungent oils are employed externally against paralytic complaints, numbness, pains, and aches, cold tumours, and in other cases where particular parts require to be heated or stimulated. The toothache is sometimes relieved by a drop of these almost caustic oils, received on cotton, and cautiously introduced into the hollow tooth.

Oil of Vitriol. The old and erroneous name for Sulphuric Acid, which see.

Olefiant Gas, was discovered at Haarlem, in 1796, by the associated Dutch chemists, and received its present name from its property of giving rise to a substance resembling oil, when mingled with chlorine (*oleum fio*). It is sometimes called *bi-carbureted*, or *per-carbureted hydrogen*. It is prepared by mixing in a capacious retort, six measures of strong alcohol with sixteen of concentrated sulphuric acid, or one measure of common alcohol and three of ordinary oil of vitriol or weak sulphuric acid, and heating the mixture over an argand lamp. The acid soon acts upon the alcohol; effervescence ensues, and olefiant gas passes over. At the commencement of the process, the olefiant gas is mixed with a little ether; but in a short time the solution becomes dark, the formation of ether declines, and the odour of sulphurous acid begins to be perceptible; and towards the close of the operation, though olefiant gas is still the chief product, sulphurous acid is freely disengaged, some carbonic acid is formed, and charcoal in large quantities deposited. The olefiant gas is collected

over water or mercury. The greater part of the ether condenses spontaneously; and, the sulphurous and carbonic acids may be separated by washing the gas with lime-water or potash. The olefiant gas, in this process, is derived solely from the alcohol; and its production is owing to the strong affinity of sulphuric acid for water. Alcohol is composed of carbon, hydrogen and oxygen; and from the proportion of its elements it is inferred to be a compound of eight parts, or one equivalent of oxygen gas united with one equivalent, or nine parts of water. It is only necessary, therefore, to obtain olefiant gas, to deprive alcohol of the water which is essential to its constitution; and this is effected by sulphuric acid.

Olefiant gas is a colourless, elastic fluid, which has no taste, and scarcely any odour when pure. It extinguishes flame, is unable to support the respiration of animals, and is set on fire when a lighted candle is presented to it, burning slowly, with a dense white light. With a proper quantity of oxygen gas, it forms a mixture which may be kindled by flame or the electric spark, and which explodes with great violence. On conducting this experiment with care, it is found that, for each measure of olefiant gas, precisely three of oxygen are required, when the mixture wholly disappears, giving rise to a deposition of water and two measures of carbonic acid. Olefiant gas, by weight, consists of

Carbon, ...	25.418
Hydrogen, ...	4.236

When olefiant gas is mingled with chlorine in the proportion of one measure of the former to two of the latter, they form a mixture which takes fire on the approach of flame, and which burns rapidly, with the formation of muriatic acid gas, and deposition of a large quantity of charcoal. But if the gases are allowed to remain at rest after being mixed together, a very different action ensues. The chlorine, instead of decomposing the olefiant gas, enters into direct combination with it, and a yellow liquid, like oil, is generated. This substance is sometimes called *chloric ether*; but the term *hydro-carburet of chlorine*, as indicative of its composition, is more appropriate. To obtain it pure, and in a dry state, it should be well washed with water, and then distilled from chloride of calcium. As thus purified, it is a colourless, volatile liquid, of a peculiar sweetish taste, and ethereal odour. Specific gravity, 1.2201. It boils at 152° Fahr., and may be distilled without change. Its composition is

Chlorine, . . .	2.5	36 one proportion;
Olefiant gas, . .	0.9722	14 one proportion.
	3.4722	50

From an observation made by professor Silliman, that the chloric ether is readily soluble in alcohol, imparting to it its peculiar sweet taste, and forming with it a grateful diffusive stimulant. Mr. Guthrie, an American chemist, was led to attempt the manufacture of this etherized spirit in a more economical way, in which he fully succeeded. The following is his process :—Into a clean copper still, put three pounds of chloride of lime and two gallons of alcohol, of specific gravity .844, and distil. Watch the process, and when the product ceases to come highly sweet and aromatic, remove and cork it up closely in glass vessels. The remainder of the spirit should be distilled off for a new operation. The quantity of ethereal spirit afforded is one gallon. So far as the effects of this new stimulant have been tried, it is found to be singularly grateful, both to the palate and stomach, producing promptly a lively flow of animal spirits, and leaving, after its operation, little of that depression consequent to the use of ardent spirit.

Olefiant gas unites with iodine, by exposing it to the vapour of iodine in the direct rays of the sun. The *hydro-carburet* of *iodine* thus formed is a solid, white, crystalline body, which has a sweet taste and aromatic odour, It consists of

Iodine, ...	124, or one proportion;
Olefiant gas	14, or one proportion.

A *hydro-carburet* of *bromine* is also formed by adding one part of hydro-carburet of iodine to two parts of bromine, contained in a glass tube. Instantaneous re-action ensues, attended with disengagement of caloric and a hissing noise; and two compounds, the bromuret of iodine and a liquid hydro-carburet of bromine, are generated. The latter, after being washed with a solution of potash, is colourless, heavier than water, very volatile, of a penetrating ethereal odour, and an exceedingly sweet taste, which it imparts to water. This compound is also formed by letting a drop of bromia fall into a flask full of olefiant gas.

Oleic Acid.—When potash and hog's lard are saponified, one portion of the alkali separates in the form of a pearly-looking solid, while the fluid fat remains in solution, combined with the potash. When the alkali is separated by tartaric acid, the oily principle of fat is obtained, which is purified by saponifying it again and again, recovering two or three times, by which means the whole of the margarine is separated. As this oil has the property of saturating bases, and forming neutral compounds, it is called an acid. It is an oily fluid, without taste and smell; specific gravity 0.914. 100 of the oleic acid saturate 16.58 of potash, 10.11 of soda, 7.52 of magnesia, 14.83 of zinc, and 13.93 of peroxide of copper.

Olives. This fruit is in its natural state bitter, acid, and exceedingly disagreeable; though its taste is much improved when pickled, as we receive it from abroad, particularly the smaller kind, or Lucca olives. Those of Florence are esteemed excellent; but on account of the abundance of oil they contain, they are not adapted to delicate stomachs, and are pernicious, especially when eaten as a dessert, after a heavy dinner. Though pickled olives are grateful to the stomach, and are supposed to promote appetite and digestion, the ripe ones are more eaten among the Greeks, forming a considerable part of their food, especially in Lent. There are three kinds of olives frequently sold, different in size and quality; namely, those of Verona, those of Spain, and those of the south of France.

Olla Podrida; a favourite dish of the Spaniards, consisting of several kinds of meat cut up and stewed together. The same name is also given to a vase of odoriferous flowers and herbs. It is often used, metaphorically, to denote a medley.

Omnium; a term in use among stock-brokers and speculators in the funds, to express the whole of the articles which the subscribers to a loan receive from government. Thus, if the subscribers, according to their agreement with government, are to have, for every hundred pounds advanced, a certain sum in

three per cent. consols, a further sum in four per cents., and a proportion of the long annuities, the blank receipts which they receive for making the instalments on the several articles, are, when disposed of independently of each other, as the three per cent. consols only, called *scrip* (a contraction of *subscriptions*); when the receipts are sold together as originally received, they are usually called *omnium*. As the omnium of every loan is the subject of extensive speculations, it generally is liable to considerable variations with respect to its current price, sometimes selling at a high premium, at other times at a discount, according to the circumstances which take place between the agreement for the loan and the day fixed for paying the last instalment.

Opera. The opera is a musical drama. The music makes an essential part of it; and in this it is distinguished from other dramas accompanied by music. Song and music may be said to be the poetry of the opera, and, though the opera remains a drama, and never ought to lose this character, yet, as music is lyrical, the opera must be principally directed to the expression of feelings and passions. Comparatively little display of character and action can be expected from it. An opera, like every work of art, must bear the stamp of unity: one character must prevail through the whole, as the soleman and grave in Mozart's Magic Flute (though there are *naïf* passages interspersed in it), or the glowing, vivid colouring of Figaro, or the heroic elevation of Gluck's *Alceste*. It is further necessary to give individuality of character by means of the music, and the lyrical monologues (airs, *cavatine*, *ariosos*) and dialogues (*duettos*, *terzette*, &c.) must alternate in pleasing variety. But our limits do not allow us to give a description of the various parts requisite to these exquisite productions.

According as the serious or the comic character prevails in the opera, it is termed *opera seria* or *opera buffa*. There is also a style—*mezzo stilo*—between both, the limits of which it is, of course, impossible to define. *Grand opera* is the name given to that kind which is confined to music and song. The *recitativo* is an essential part of this. By *operetta* is understood a short musical drama of a light character. The Italians have a species of musical dramas called *intermezzo*. The French *vaudeville* belongs to this species of compositions, but not the German melodrama, in which music, indeed, is introduced either by itself, or in connection with the dialogue, but no singing takes place.

Origin of the Italian Opera.—About the year 1594, three young noblemen of Florence, who were attached to each other by a similarity of tastes and pursuits, and a love of poetry and music, conceived the idea of reviving the chanted declamation of the Greek tragedy: they induced the poet Rinuccini to write a drama on the story of Daphne, which was set to music by Peri, the most celebrated musician of the age, assisted by count Glacomo Corsi, who, though only an amateur, was also, for the period, a good musician: the piece, like the Mask of Comus, was privately represented in the palace of Corsi. The interlocutors, or singers, were the author and his friends; and the orchestra of his first opera consisted but of four instruments, viz. a harpischord, a harp, a *viol di gamba*, and lute. There was no attempt at airs; and the *recitative*—if such it could be called—was merely a kind of measured intonation, which would appear to us insufferably languid and monotonous; yet it caused, at the time, an extraordinary sensation, and was frequently repeated. Four years afterwards, the first public opera, entitled *Euridice*, written by the same poet, and set by the same musician, was represented at the theatre of Florence, in honour of the marriage of Mary de' Medici with Henry the Fourth of France. On this occasion, the introduction of Anacreontic stanzas, set to music, and a chorus at the end of each act, were the first imperfect indications of the airs and choruses of the modern opera. Monteverde, a Milanese musician, improved the recitative, by giving it more flow and expression; he set the opera of Ariadne, by Rinuccini, for the court of Mantua; and in the opera of Glasone, set by Cavili and Cicoguini, for the Venetians (1649), occur the first *airs* connected in sentiment and spirit with the dialogue. According to another account of the origin of the opera, John Sulpitious, about 1486, exhibited short dramas, accompanied with music, in the market-place at Rome, and also before the pope and some cardinals.

The commencement of the *opera seria* at Rome reminds us of the waggon of Thespis and his lees-besmeared company of strollers. The first performance of this kind, consisting of scenes in recitative and airs, was exhibited in a cart during the carnival of 1606, by the musician Quagliata and four or five of his friends. The first regular serious opera performed at Naples was in 1615: it was entitled *Amor non ha Legge*. During the next half century, the opera not only did not improve, but it degenerated: it became in Italy what it was in France during the last century—a grand spectacle addressed to the eye, in which the poetry and music were the last things considered, while the scenery, méchanical illusions, and pantomime, were on the most splendid scale. As Goldoni said long afterwards of the grand opera at Paris, *C'était le paradis des yeux et l'enfer des oreilles.*

The first *opera buffa* is said to have been represented at Venice in 1624, where also the first stage for operas was erected (in 1637). In 1646, the opera was transplanted to France by Cardinal Mazarin. In Germany, carnival plays, in which the performance consisted of singing, existed even in the times of Hans Sachs, who died in 1567. Opitz and others imitated the Italian pieces; but the first German original opera is said to have been Adam and Eve, played at Hamburgh, in 1678. Some consider The Devil let loose the first comic opera in Germany. In Sweden, the first Swedish original opera was performed in 1774. The Italian opera was introduced into England in the seventeenth century. Handel then effected a revolution here, which, however, did not exert a permanent influence on the English opera. The Italian opera did not penetrate into Spain. until the second half of the eighteenth century. The Italians draw the line between the *opera seria* and *opera buffa* much more distinctly than the Germans, so that the Italian *opera seria* appears almost insipid to a German; the *buffa*, on the contrary, is quite grotesque and quite national, and produces a lively effect when played by Italians. The compositions of Rosini are now considered as master-pieces in the modern Italian school: and Weber, that of Germany.

Ophthalmia; an inflammation of the mucous membrane which covers the globe of the eye and of the correspondent surface of the eyelids. It differs very much in its exciting causes. Residence in damp or sandy countries, exposure to the sun, and sudden

changes of weather, are among the most usual causes. Its characteristic marks are pain and redness. Ophthalmia is either *acute* or *chronic*; the one arising from an excess of stimulus and re-action of the living solid, the other connected with debility which is generally limited to the vessels of the parts affected, but sometimes extends to the whole system.

The presence of acute ophthalmia, in a mild degree, may be inferred from the suddenness of its occurrence, the mildness of its attack, and the *absence* of any *previous* disease, local or constitutional, such as erysipelas, syphilis, scrofula, rheumatism, or gout. If inflammation came on suddenly a sensation is felt that suggests the idea of sand being between the lid and the eye-ball, a profuse discharge of tears; if these symptoms be increased by exposure of the eye to the rays of light, solar or artificial; if there be heat and redness of the eye itself, the nature of the case is evident, and it demands the immediate application of leeches, which, in young children, should be employed with great caution, and in small numbers (one to each lid); in adults, from two to eight, or ten, may be applied, according to the severity of the symptoms: it will be well to apply two or three on the upper lid of the affected organ, and four to the lower lid; some should also be applied to the temple of the affected side. After the application of the leeches, apply a blister behind one or both ears. A brisk purgative (if the patient be strong), containing calomel and rhubarb, should be immediately given, and be repeated in twenty-four hours. A mixture of one ounce of Epsom salts, two drachms of nitre, and one ounce of antimonial wine, with a pint of cinnamon water, should be prepared, and the patient, if an adult, should take, according to the vigour of his constitution, from one tablespoonful to one wine glassful, every three, or four, or five hours. If a young person, of course the dose and frequency of taking must be diminished and regulated according to circumstances. The diet should be mild, and without meat and fermented liquors. The eyelids and part of the forehead should be kept constantly covered with lint dipped in goulard-water. These measures will generally abate the acute inflammation in twenty-four or thirty-six hours; after which time the treatment may be moderated, and the mixture taken less frequently. When the pain is much diminished, the heat and swelling less, and the eye is more tolerant of light, the cold lotion may be omitted, and a green shade substituted; the eye often bathed with cold spring water; and once or twice a day the following lotion to be used by means of a glass eye-cup. Sulphate of zinc, five grains; rose-water, four ounces: after using this for several days, the strength of this lotion may be doubled.

When the acute ophthalmia changes into the chronic one, attended with local weakness, it is highly important, in the treatment, to substitute for topical emollient, relaxing applications, such as partake of an astringent, corroborant quality. That chronic ophthalmia may depend upon a morbid irritability of the eye is evinced, not only from its resisting topical astringents and corroborants, to which the disease from simple relaxation and weakness yields, but from its being exasperated by them, and even by cold water. The patient complains of a sense of weight in the upper eyelid, and restraint in opening it; the conjunctiva has a yellowish cast, and when exposed to the damp cold air, or a brilliant light, or when a patient studies by candle-light, its vessels become filled with blood. If in combination with such symptoms, the habit of body be weak and irritable; subject to spasms; hypochondriasis, &c., then it is manifest, that the chronic ophthalmia is connected with a general impairment of the nervous system.

When the chronic ophthalmia depends upon preternatural irritability, the internal exhibition of bark with valerian is proper; animal food of easy digestion; gelatinous and farinaceous broths; wine in moderation; gentle exercise; living in salubrious and mild situations; are all severally productive of benefit. Externally, the applications should be of the sedative and corroborant kind; such as aromatic spirituous vapours applied to the eye through a funnel, for half an hour, three or four times a day; and the eyebrows and eyelids may also be rubbed with a liniment of camphor. Patients, both during the treatment and after the cure, must refrain from straining the eye, and, immediately the least uneasiness is felt, must desist from exercising it. When they write, or read, it should constantly be in a steady uniform light, and too little, as well as too much, aggravate the disease. Having once begun to use spectacles, they should never study, or survey minute objects, without them.

Opium; the inspissated juice of a species of poppy, a native originally of the East, but naturalized throughout the greatest part of Europe. The capsules contain a prodigious number of seeds. It is found in most gardens as an ornamental plant, and is, besides, cultivated extensively in many parts of Europe, but only for the sake of the oil which is obtained from the seeds. It is from the East, from the different parts of the Turkish empire, and from Hindoostan, that the opium of commerce is chiefly procured.

In many provinces of Asia they sow the white poppy (for this is the variety from which the true opium is procured) as we sow wheat. As soon as the heads appear, a slight incision is made in them, and some drops of a milky fluid exude, which are suffered to dry, and then collected. Tournefort tells us, that the greatest quantity of opium is made by bruising and pressing the heads; but Kæmpfer and Belon, though they speak of three kinds of opium, describe each as produced by incision and exudation only. In Persia, the opium is collected in summer, when the heads are nearly ripe; and these are wounded on one side by a knife, which makes five incisions at once. The next morning the inspissated juice is collected with a spatula. The operation is then repeated on the other side of the heads, but the first tears, styled *gobaar*, are preferred: these are whitish, or of a light yellow, but become brown in the sun, or when too much dried. The second tears are darker, and less efficacious; those of the third operation, black and inefficacious.

When the opium is collected, it is beat up with a little water or honey, till it has the consistency of pitch. It is then rolled into cylinders, and, in this state, offered for sale. If small quantities are wanted, they are cut off with scissars. Sometimes the honey is in so large a proportion as to prevent its drying, and to soften its bitterness. The most remarkable preparation of opium in the East, is uniting it with nutmeg, cardamoms, canella, and mace. It is called *philonia*, and is the philonum of the Persians, sup-

posed to strengthen the heart and the brain. Others add only saffron and ambergris; and almost every one varies the additions according to his fancy. A celebrated liquor, called *Cocomar*, is mentioned by Kæmpfer, which is an infusion or a decoction of the leaves, sometimes of the heads, adding various ingredients to please the palate. Another preparation to produce a temporary intoxication is called an electuary, and often employed in the East.

Olivier, in his travels into Asia, saw the plantations of poppies on a large scale, chiefly in the vicinity of a village called Affiom Kara-Hissar (the black castle of opium). The poppy is sown in autumn, transplanted in spring, and the harvest is collected about July.

The preparation of opium in Britain has long been a desideratum. Premiums have been offered by the Society of Arts, and more recently by the Caledonian Horticultural Society. Specimens of British opium have been produced, and proved to be in no degree inferior to the best foreign opium: but it has not yet been ascertained whether this valuable drug can be cultivated on the large scale with profit to the grower. The earliest experiments were conducted according to the eastern mode. But to this mode of cultivation the temperature, winds, and rain of this climate, have hitherto been justly considered as great obstacles. Of these the temperature may be held as the least objectionable; for the large white poppy, from which foreign opium is obtained, comes to maturity in our climate. But it is further objected that the high winds beat down the plants, and the rains wash off the opium, before it can be collected, when the eastern mode of gathering it is practised. It has therefore been proposed to cultivate the garden poppy of this country, because it is not so liable to be damaged by wind as the large white poppy.

It is our present object to describe a method by which these obstacles have been completely removed, and to demonstrate, from the result of experiment, that opium, superior in quality to the best Turkey opium, can be procured in Britain in sufficient quantity, not only for home consumption, but also for exportation.

As the method of gathering opium about to be described differs materially from any other previously in use, it may be proper to observe that Mr. Ball, who obtained a premium of fifty guineas from the Society of Arts, collected his opium according to the Bengal method, which is accurately described by Mr. Kerr, who was an ocular witness, and by Mr. W. Davis, whose accounts agree with that given by Kæmpferius respecting the mode of collecting opium in Persia. The seeds, according to Mr. Kerr, are sown in quadrangular areas, the intervals of which are formed into aqueducts for conveying water into each area. The plants are allowed to grow six or eight inches from each other, and are plentifully supplied with water till they are six or eight inches high, when a nutrition compost of dung, ashes, and nitrous earth, is laid over the areas. A little before the flowers appear, they are again well watered, till the capsules are half grown, when the watering is stopped, and they begin to collect the opium. This they effect by making, at sunset, two longitudinal incisions from below upwards, without penetrating the cavity, with an instrument that has two points as fine and as sharp as a lancet. The incisions are repeated every evening, until each capsule has received six or eight wounds, and they are then allowed to ripen their seeds. The juice which exudes is collected in the morning, and being inspissated to a proper consistence, by working it in an earthen pot in the sun's heat, it is formed into cakes for sale. In this manner Mr. Ball collected four ounces of opium from one fall and twenty-eight square yards of ground, which is at the rate of 22 lbs. 8 oz. per acre.

It is probable that Mr. Thomas Jones, who was a candidate for the premium offered by the Society of Arts, was misled by the speculations of Mr. Ball. Mr. Jones collected only 21lbs. 7 oz. of opium from five acres and upwards of poppies, and obtained the premium of fifty guineas for the largest specimen. He collected his opium according to the Bengal method; but some of his poppies, he says, became stunted, and others were entirely destroyed by remarkably dry weather, which continued six weeks from the beginning of May. This may be considered as the reason why he obtained so little from five acres. In another place he says that the largest quantity which his man, seven children, and himself, were able to procure in one morning, from five to nine o'clock, was one pound and a half. This happened when the dew was remarkably great, and succeeded one of the warmest days of the summer. And, as he admits in another place that the opium (which appeared upon the heads in a soft ash-coloured substance), when first collected, is, from its union with the dew, much too soft to be formed into a proper consistence, making a proper allowance for the evaporation of its watery part, it may be concluded that he gathered only in one morning, after a warm day, in the same ratio that they gather opium in the East Indies. They have no rain in India during the season of gathering opium, and Mr. Kerr says that there one acre of poppies yields 60 lbs. of opium.

Dr. Howison, who was some time inspector of opium in Bengal, gave an account of the result of his experiments for making opium in this country. Although he was not the first who collected the milky juice of the poppy in a fluid state, it is supposed he is the first who, in this country, has given the preference to that mode. Dr. Alston collected the milky juice in the fluid state according to Dioscorides, and also in the Persian way described by Kæmpferius, from several varieties of the poppy. He also collected the true tear, as he calls it, by cutting off the star of several heads, bending them down, and suffering the milk to drop into a tea-cup; yet he says that he collected most by the Persian way.

The instrument used by Dr. Howison for wounding the poppy-heads consisted of a brass ring, mad to fit the middle finger of the operator, in which is fixed a wheel set with lancets, which, when put in motion by drawing the hand along the poppy head, makes with great expedition whatever number of perforations are wanted, each giving out its distinct drop of milk, by which a great surface is affor ed, both for support and evaporation, and to prevent the flowing milk from running upon the ground, *the unavoidable consequence of the method formerly in use.* And for gathering the opium he employed a ti flask, flattened at the mouth about half an inch, with which he *scraped* off the opium. By means of these instruments, Dr. Howison obtained a cake of opium that weighed 8½ oz., and which was collected from a field of poppies measuring about five falls, which is at the rate of 17 lbs. weight of opium per acre.

Dr. Howison's puncturing instrument and collecting flask may certainly be considered as a material improvement upon the Hindoo instruments, and he found that they answered his purpose to a certain extent in gathering opium from the garden poppy. But, when the unevenness upon the surface of the capsules of the white poppy is considered, it will be found impossible to adapt the mouth of the flask so as to collect the whole of the juice without materially injuring the capsule, and much of the juice would still remain in the interstices of the ridges, which are for the most part found upon the capsules of the white poppy. Besides, the juice very soon acquires a ropiness, and adheres to the mouth of the flask, which must interrupt the gathering, and there is a chance of the juice being spilt by having the flask suspended to the body of the gatherer.

Dr. Howison has stated several objections to the cultivation of the large white poppy in this country, and has given the preference to the double red garden poppy and its varieties. He says that the white poppy, from its large head and very considerable height, is of all others the most liable to be hurt by winds; and unless they be cultivated in a sheltered situation, few will be found standing when the season for gathering the opium arrives. But, independent of this, he says that it never arrives at such perfection in this climate as to yield milk of proper consistence for making good opium, and that the few that do come to afford milk continue in that state only for a day, and any attempt to bleed them a little sooner or later would be without success.

Mr. Kerr, however, informs us that the large white poppy grows in Britain, without care, to be a much statelier plant than it does in India with the utmost art; and Dr. Alston, after commenting upon the controversy whether opium is obtained from the white poppy or from the black, concludes that as a medicine it is of no consequence whether it be taken from the one or from the other. Dr. Crump also observes that the white variety is to be preferred, as affording opium in greater quantity than any of the rest; and there can be no doubt that this poppy yields the largest and most juicy heads.

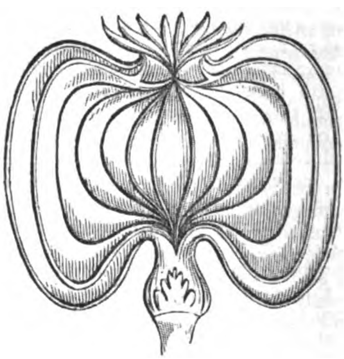
Dr. Howison has stated that 200,000 lbs. of opium are made annually in Bengal; and that, notwithstanding all the care that is taken in collecting it, one-third of the crop is lost: but there is reason to believe that the waste is much greater than he supposes; for, in whatever way the incisions are made, the milky juice instantly flows in a wasteful stream, and, by running upon the ground or upon the leaves, one-third of the crop at least must be lost before the gathering commences in the morning. "In this climate, "he remarks," where the serenest day is often followed by a night of deluging rains, the adoption of the Bengal method would be worse than trusting our fortune to the chance of a lottery."

Although Dr. Howison was convinced that the juice of the poppy undergoes no change in its properties by exposure to the air, further than acquiring a greater consistence from the evaporation of its watery part, he states in another place that in Bengal, where there is no rain during the opium gathering season, the custom of allowing the milk to thicken, by remaining for some time on the capsule, is highly judicious; while, in another part of his account, he admits that that custom is the only reason why they lose one-third of their crop.

Supposing that if 200,000 lbs. of opium give the East India Company 100,000*l.* sterling annually, by Dr. Howison's account they thus lose more than 30,000*l.* But, were the loss to amount only to half that sum, sufficient importance, it is to be supposed, would be attached to the means by which such a saving could be effected.

Mr. Kerr states that there are about 600,000 lbs. of opium annually exported from the Ganges, independent of what is consumed in the interior. He also states that it is frequently mixed with cow-dung, the extract obtained by boiling the plants, and other additions, which are kept secret. It is, indeed, frequently so much adulterated that considerable quantities are burnt at Calcutta by order of the Government.

Mr. Young, in a valuable paper on the preparation of opium, thus describes his own experiments. To render his process intelligible it may, however, be advisable to give a section of the capsule, showing the relative situations of the seeds and external rind, from whence the narcotic principle is obtained:—



"In the summer of 1817, I cultivated a small field of poppies, containing about 20,000 plants of the papaver somniferum of Linnæus, out of which I selected two beds, measuring one fall and fourteen square yards, for the purpose of ascertaining what quantity of opium it would produce. I collected the opium from that part selected for the experiment myself, while the rest of the crop was gathered by the people I employed. I collected as much of the milky juice as was equal to one drachm of solid opium in the space of an hour; but, as my professional avocations prevented me from regularly superintending the people at work, they did not gather so much as I expected. I ascertained, however, that they could gather at the rate of one drachm in the hour.

"I had my poppies sown in three different ways. The first, broad-cast upon beds three feet wide, with an alley between, and thinned out to the distance of four and five inches when the plants were about two inches high above the ground. The second on beds three feet wide, in rows, six rows to a bed, and six inches between the plants. The third, on the spaces between rows of asparagus, two rows of poppies on each space, eight inches between each row, and six inches between the plants; two feet four inches between each double row of poppies occupied by the asparagus.

"The first produced only one capsule, the second two, and the third three capsules. Having ascer-

tained that the white poppy, when cultivated upon the wide drill plan that I have adopted, not only gives out more capsules, but much larger ones than when cultivated in the broad-cast way, or close rows; it is evident there must be a great saving of labour, for it will take as much time to gather the juice from a small head as it would do to collect three times the quantity from a large head.

"The plants between the asparagus rows, having more room to grow, had not only more capsules, but they were much larger than those sown broad-cast or in beds in close rows; and as early potatoes, cultivated in a piece of ground adjoining my crop, were sold for a high price before my plants began to flower, I proposed the following year to have, by this mode of culture, the same quantity of opium with a crop of early potatoes, as I obtained from an equal measurement of ground where there was nothing but poppies. Accordingly, in 1818, I selected a piece of ground in the highest state of cultivation, well manured with horse-dung, in which I planted early potatoes, in rows four feet wide. Furrows were first drawn; in these furrows the dung was laid; then the sets were dropped on the dung, about nine inches asunder, and covered by the hoe. The potatoes were planted the first week of February, and the poppies were sown about the middle of April, on the middle space between the potato rows, two rows of poppies on each space, and twelve inches between the rows. When the poppy plants were about two inches above the ground, they were at first thinned out by the hoe, and afterwards by the fingers, to the distance of eight inches between the plants.

"In this manner I raised a crop of early potatoes equal to 36 bolls per acre. Although the potatoes will be ready for immediate use before the gathering of opium commences, the whole crop will not be entirely ripe for lifting till after the opium is collected. The early potato gives out but a small stem, but where the soil is rich some of them may spread in the areas, yet they can be easily pushed over to one side, so as to allow the opium gatherers to walk along the areas without trampling upon them.

"The distance between the poppy plants being wider than last year, upon an average they produced four full-grown capsules each, and some of them produced seven or eight capsules; and I gathered this season at the rate of two drachms of solid opium in one hour, while, by the same method of gathering, I could not collect more than one drachm in the same time last year.

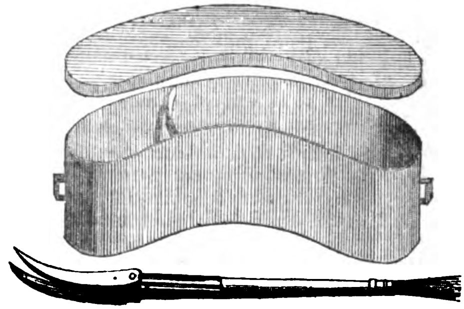
"Supposing one acre had been cultivated in the same manner as that piece of ground on which my experiment was made, the produce in that case would have been equal to 57 lbs., 9 oz. 4 drs., and 48 grs. of solid opium, which is just twice as much as I collected the year before. But the season of 1818 being so much more favourable than the preceding year will in a great measure account for the success of this experiment. Therefore the quantity of opium that may be collected depends greatly upon the season; yet the comparative view of the result of the experiment made in 1817, although the season was extremely unfavourable, is sufficient to prove that my method of extracting and gathering opium has a decided advantage over any other that has been recommended.

"As my poppies were sown about the middle of April, they were ready for bleeding about the middle of July.

"For making the incisions, I use a double-bladed convex-edged knife, having all the blade covered with sealing-wax, except so much of the cutting edge as is sufficient for wounding the external rind of the capsule, without penetrating its cavity, and with which I make one or more double incisions, according to the size of the head, at first longitudinally, and afterwards obliquely upwards from the stalk. This operation commences about a week after the flowers fall, when the capsules discovér to the pressure a proper degree of hardness.

"The instrument I used consisted of two convex-edged scalpels, the blades of which were covered with sealing-wax, except about one-sixteenth part of an inch of the edge, and, being wound round the handles with waxed thread, the two were fastened together with other thread twisted round them, and thus held at the distance of about half an inch between each blade."

We have preferred giving a description of Mr. Young's instrument in his own words, as they occur in the paper, but it may be proper to observe that the form he really recommends is shown in the engraving beneath. There is also a representation of the tin flask, with a bridge to remove the opium from the brush which is attached to the opposite end of the knife.



"When the capsule is sufficiently scarified in the manner described, I then cut off, with a sharp scalpel, the capitellum or star, with a thin slice of the external rind round it, and by this last incision I obtained more juice than from a scarification upon the side of the head.

"It is my method of gathering the milky juice of the poppy in the fluid state that differs materially from any other that has been used, and it is on that account that I have been more successful than any other that has tried the experiment.

"In my communication to Dr. Duncan, relative to lactucarium or lettuce-opium, published in the second edition of his *Observations on Pulmonary Consumption*, I proposed to gather the opium by means of a sponge. But, when I began to collect opium in that way, I soon found that it would not do; for, although the sponge removes the juice more effectually than the flask proposed by Dr. Howison, it cannot be again entirely expressed, because the sponge decomposes or separates the component principles of the milky juice, and the resinous part adheres to the sponge and soon clogs its pores. I therefore adopted the use of a small common hair brush used by painters, and known to the trade by the name of a sash-tool, which answers the purpose most completely, and with which I gathered the

milky juice, even though some of the plants were laid by wind and rain, as well as if they had been standing erect. I used a camel-hair brush, but found the same objection to it as to the sponge. The common sash-tool, rounded a little at the point, without being ground, is that which I prefer.

"For the sake of experiment, I exposed myself one morning to a shower of rain for half an hour, while making the incisions and gathering the opium, and succeeded as well as when there was no rain.

"When the brush is sufficiently charged with juice, I scrape it off upon the edge of the tin flask, fastened to the breast of the gatherer, and capable of holding more than a day's gathering.

"The gatherers follow the bleeders immediately. One bleeder will occupy two gatherers, and if he be very expert he may keep three gatherers constantly employed. When I performed both operations myself, I held the knife between the thumb, fore and middle fingers, and the brush between the ring and little fingers of the right hand, while I held the poppy by the stalk with the left hand.

"The juice is afterwards formed into cakes or balls by spontaneous evaporation in shallow earthen dishes, placed in a close room, stirring it occasionally during the evaporation of its watery part, to be afterwards kept in bladders.

"The operation for gathering cannot be repeated with advantage oftener than three times a week upon the same capsules; for no more juice will flow from one wound than what may be collected immediately, and a certain time must elapse before the plant forms more juice. But it is evident a number of hands may be kept constantly employed upon a large field, till the plants cease to give out juice.

"One acre will keep twelve gatherers and six cutters constantly employed for thirty days. That number can only gather a third part of an acre in one day, and by the time they have gone through the crop, the capsules at that place where they began to gather will be ready for the operation being repeated; so that, when the milky juice ceases to flow, five operations, as already described, will have been made upon each capsule.

"Supposing twelve gatherers to work ten hours in the day, and that each gathers two ounces and a half, or as much of the juice as will make that quantity of solid opium, in thirty days they will gather fifty-six pounds of opium from one acre.

"One acre of poppies, cultivated according to my method, will yield 1000 lbs. of seed, and this quantity of seed will give by expression 375 lbs. of oil."

Although the produce of such a crop has not yet been clearly ascertained upon a large scale, the following may be taken as the estimate of one acre, from what has actually been produced in Mr. Young's experiment.

Estimated value of the produce of one acre.

56 lbs. opium, at 36*s*.	£100	16	0
36 bolls early potatoes, at 24*s*. . .	43	4	0
250 lbs. of oil, cold drawn, at 1*s*. 6*d*. .	18	15	0
125 lbs. ditto warm, at 6*d*. . . .	3	2	6
500 oil-cakes, at 18*s*. per 100 . .	4	10	0
	£170	7	6
Expenses,	60	0	0
Total of profit,	£110	7	6

Or it may be taken this way.

56 lbs. opium, at 17*s*. 6*d*. . . .	£49	0	0
36 bolls of potatoes, at 24*s*. . .	43	4	0
250 lbs. of oil, cold drawn, at 1*s*. 6*d*. .	18	15	0
125 lbs. ditto warm, at 6*d*. . .	3	2	6
500 oil-cakes, at 18*s*. per 100 . .	4	10	0
	£118	11	6
Expenses,	60	0	0
Profit,	£58	11	6

A few facts illustrative of the chemical and medicinal properties of opium must conclude our article. Opium contains acidulous meconate of morphia, extractive matter, mucilage, fecula, resin, fixed oil, caoutchouc, a vegeto-animal substance, debris of vegetable fibres, occasionally a little sand, and small white pebbles, together with the white crystalline salt of opium, now known under the name of *narcotine*. If we treat opium first with abundance of ether, a tincture of a deep yellow shade is obtained, from which there gradually falls a powder, insoluble in water, alcohol, and ether, and, when distilled, it affords a considerable quantity of ammonia. The ethereous tincture, freed from this yellowish powder, yields, on evaporation, crystals impregnated with a viscid oil, among which small masses, of more consistence, are seen to float. These are caoutchouc, which may be separated from the oil by a fine tube. The oily liquid is to be decanted, in order to insulate the crystals, which are then treated with boiling alcohol. On cooling, this affords the narcotine, slightly impregnated with caoutchouc. From this a new solution frees them completely. Hence, by this process, are eliminated four different products: 1. a fixed oil; 2. caoutchouc; 3. a vegeto-animal substance; 4. narcotine. The opium, after being thus exhausted by ether, when dissolved in water, affords solutions equally acid as ordinary opium, and which comport themselves with magnesia or ammonia as if no ether had been applied to it. (See MORPHIA.) It is obvious, therefore, that the two crystalline bodies, narcotine and morphia, exist in opium quite independent of each other.

The external and internal effects of opium appear to be various in different constitutions, and in the same at different times. By some, when applied to the tongue, the nose, the eye, or any part deprived of skin, it has been said to stimulate and to induce in the eye in particular a slight degree of redness. But, if this effect do take place, it is at the utmost extremely inconsiderable, particularly when compared with the effect of a variety of other articles applied to the same organ; and there can be no doubt that in a very short time the sensibility of the part to which it is applied, even when there has not taken place the slightest mark of preceding stimulus or inflammation, is very considerably diminished. Some allege that when applied to the skin it allays pain and spasm, procures sleep, and produces all the other salutary or dangerous effects which result from its internal use; while others allege that thus applied it has little or no effect whatever.

It sometimes allays the pain from a carious tooth, by deadening the sensibility of the part, which is sufficient to prove that this is occasionally useful as a local remedy.

Opium, when taken into the stomach to such an

extent as to have any sensible effect, gives rise to a pleasant serenity of mind, in general proceeding to a certain degree of languor and drowsiness. The action of the sanguiferous system is diminished, the pulse becoming for the most part softer, fuller, and slower than it was before. There often takes place a swelling of the subcutaneous veins, and sweating; both probably the consequence of a diminution of resistance at the surface, from a diminution of muscular action; and accordingly opium diminishes those discharges which depend on muscular action, as is particularly exemplified in its effects on the digestive organs. Opium taken into the stomach in a larger dose gives rise to confusion of the head and vertigo. The power of all stimulating causes, of making impressions on the body, is diminished; and, even at times and in situtions when a person would naturally be awake, sleep is irresistibly induced. In still larger doses, it acts in the same manner as the narcotic poisons, giving rise not only to vertigo, headache, tremors, and delirium, but to convulsions also; and these terminate in a state of stupor, from which the person cannot be roused. This stupor is accompanied with slowness of the pulse, and with stertor in breathing, and the scene is terminated in death, attended with the same appearances as take place in apoplexy.

From these effects of opium in a state of health, it is not wonderful that recourse should have been had to it in disease, as mitigating pain, inducing sleep, allaying inordinate action, and diminishing morbid sensibility. That these effects do result from it is confirmed by the daily experience of every observer: and as answering one or other of these intentions, most, if not all, of the good consequences derived from it in actual practice are to be explained. If, therefore, by a sedative medicine, we mean an article capable of allaying, assuaging, mitigating, and composing, no substance can have a better title to the appellation of sedative than opium.

With regard to the dose, one grain is generally sufficient: maniacal persons, and those who labour under violent spasms, require oftentimes two, three, or more grains; but it is more advisable to repeat the dose at proper intervals than to enlarge it. By frequent use, much greater quantities may be borne: the Turks, who habituate themselves to opium as a succedaneum for spirituous liquors, are said to take commonly a drachm at a time.

Dr. Hancock has published a paper in a medical journal tending to show the importance of cold water affusion in cases of poisoning with opium. Dr. Hancock commences by observing that "the superior effects of general applications (or those acting through the medium of the whole dermoid system) over the use of inward remedies are exemplified in the decisive results of cold affusion in the high state of fevers, and in cases of over-doses of opium. When the torpor, congestion of brain, and insensibility, have occurred from an excessive dose of opium, when medicines cannot be swallowed (and where, if they could, they would be useless), it is surprising to see how the patient is roused and restored to sense and muscular motion, by dashing the naked body with cold water.

"This brings to mind an interesting and instructive case, which occurred in my practice four years ago, and called forth a combination of the two potent remedies under consideration. It was a case of lock-jaw, in a black man, named Dan, at Plantation Coffee Grove, Essequibo. The disease was violent; and very large doses of opium and camphor were administered, till at length, during my absence, the administration of these remedies was carried to such an extent as not only to remove all tetanic symptoms, but also to produce the most deadly insensibility and apoplectic stupor. He was so far exhausted that the cold affusion produced but a transient effect, although it roused him for a moment from the deepest lethargy. He was then rubbed over smartly with pepper, salt, and lime-juice, which caused no signs of sensation. Again, however, dashing the body with cold water, it had more effect; by repeating the friction, and the cold affusion alternately, he was successively more excited till able to swallow an emetic, which brought up much opium and camphor. He regained his senses, had no recurrence of the spasms, and has since been tolerably healthy."

It is much to be lamented that the directions we meet with in books, for counteracting the results of excessive doses of opium, refer in general only to the methods of removing opium from the stomach, whilst no efficient means are proposed for counteracting the deleterious effects of the poison already absorbed into the system. The stomach-pump is certainly an important instrument in those cases where the torpor and the insensibility which ensue prevent vomiting, but in such cases, unless speedily resorted to, it will seldom prove effectual, although the stomach be completely emptied, instances of which are of frequent occurrence.

It may here be observed that the same means have proved equally effectual in restoring persons in the most advanced state of inebriation from excessive drinking of spirituous liquors; and any person suffering in a morning from the effects of inordinate potations may prove the efficacy of this remedy by causing a pailful of cold water to be dashed over his head and naked body. There can be but little doubt that the same remedy might prove equally successful against the effects of all other narcotic poisons, as well as opium.

END OF VOL. I.